EFFECT OF WINE FLAVOR ON THE PERCEPTION OF WINE TASTE AND PREFERENCE

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“Before a wine can be great,

it must first be true.”

Nicolas Joly

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Abstract

The present work was aimed at the evaluation of the sensory and liking responses induced by dry white wine modified with increasing flavor concentrations. The tasting panel was composed by 34 trained subjects which were characterized according to gender, smoking habits, vinotype, 6-n-propylthiouracil (PROP) status, saliva flow, sodium chloride sensitivity, tartaric acid, tannic acid sensitivity and sweet liking. Tasters scored the intensity elicited by white wine spiked with different tastants (tartaric acid, sucrose or tannic acid) or increasing levels of a fruity flavor mixture together with their liking evaluation.

The wines with different flavor concentrations were perceived increasingly sweet with constant sourness and saltiness. The tasting panel showed two groups responding differently to orthonasal flavor intensity measured as the longest distance, in cm, from the glass top where the smell is sensed. High and low smell sensitivity individuals showed equal ($p<0.05$) response to wine sweetness and wine liking while the former group provided lower sourness and saltiness scores. In addition, tasters highly sensitive to all tastes or to sucrose in wine scored aroma intensity with higher values ($p<0.05$).

Given that the increasingly flavored white wines were perceived different only in their sweetness, the liking scores could only be attributed to congruent perception of fruity flavors and sweet mouthfeel. The preference for white wine was constant across all flavor concentrations, being dependent on some taster categories. Males, non-smokers, PROP medium tasters and low saliva producers yielded higher ($p<0.05$) liking scores than the respective counterparts. The sensitivities to sourness, sweetness or astringency did not influence preference scores. The Vinotype Sensitive individuals provided higher ($p<0.05$) liking scores than hypersensitives or tolerants. In conclusion, the results suggested that taste sensitivity had only a minor role on shaping the individual preferences of white wine.

Keywords: Wine, aroma, flavor, taste, preference.

Resumo

O presente trabalho teve como objectivo determinar o efeito do flavor do vinho na percepção de gosto e preferência. Através de alterações de intensidade de aroma em vinho branco foi avaliado o efeito na percepção de intensidade de sabores básicos e de preferência de um painel de provadores treinados. O painel de provadores, composto por 34 elementos, foi segmentado de acordo com o género, hábitos de tabagismo, vinotype, 6-n-propylthiouracil (PROP), fluxo de saliva, sensibilidade a solução de cloreto de sódio, sensibilidade a solução de ácido tartárico, sensibilidade a solução de ácido tânico, sensibilidade e preferência a solução de sacarose. Os provadores avaliaram a intensidade de vinho branco aromatizado com diferentes soluções (ácido tartárico, ácido tânico e sacarose) e a intensidade e preferência de vinho branco aromatizado com concentrações crescentes de uma solução de compostos de aroma.

Nos vinhos aromatizados com crescentes concentrações de compostos de aroma foi demonstrado que a intensidade da doçura está relacionada com a intensidade aromática do vinho. As intensidades de acidez e salgado foram constantes face ao aumento de concentração de solução aromática, assim como a preferência. A intensidade aromática foi determinada pela medição da distância entre o nariz e o copo quando o indivíduo sente o aroma. O painel de provadores apresentou dois grupos distintos relativamente à resposta à intensidade aromática. Por um lado, o grupo composto por indivíduos com alta e baixa sensibilidade à intensidade aroma apresentou uma resposta idêntica ($p<0.05$) à doçura e preferência do vinho, por outro lado, outro grupo apresentou baixos valores de intensidade para acidez e salgado.

A preferência pelo vinho branco foi constante para todas as concentrações de soluções aromáticas, sendo dependente da segmentação dos provadores. Provadores homens, não fumadores, com perfil médio de PROP e baixos produtores de saliva apresentaram valores mais altos ($p<0.05$) de preferência que os restantes. Provadores com perfil Sensível de Vinotype exibiram valores mais altos ($p<0.05$) de preferência que indivíduos com perfil Hipersensitivo ou Tolerante. Em conclusão, os resultados sugeriram que a sensibilidade aos gostos apenas teve um papel parcial na determinação das preferências pelo vinho branco testado.

Palavras-chave: Vinho, aroma, flavor, gosto, preferência.

Resumo alargado

O objetivo geral deste estudo foi obter uma medida preliminar do efeito da composição volátil do vinho branco sobre alguns atributos sensoriais na boca e os gostos básicos, como o doce, ácido e salgado, bem como o efeito sobre a preferência do vinho. Em particular, os objetivos do estudo foram:

- Desenvolver um método para avaliar a intensidade do aroma de um vinho branco;
- Avaliar o efeito do aumento da intensidade aromática no vinho branco no gosto e valorização;
- Avaliar o efeito das características do provador na avaliação sensorial e na preferência do vinho branco.

Este trabalho baseou-se no treino de um grupo de provadores que foi submetido a uma segmentação de acordo com género, hábitos de tabagismo, vinotype, 6-n-propiltiouracilo (PROP), fluxo de saliva, sensibilidade ao cloreto de sódio, sensibilidade ao ácido tartárico, sensibilidade ao ácido tânico, sensibilidade e preferência à sacarose.

Trinta e quatro indivíduos (21 mulheres e 13 homens, entre 19 e 40 anos (média 24,6 ± 5,2) foram seleccionados. O painel de provadores foi composto por 12 fumadores, 3 fumadores ocasionais e 19 não fumadores.

O Vinotype é um teste realizado online que consiste num conjunto de questões que determinam as sensibilidades e as tolerâncias de um indivíduo, combinadas com questões que identificam determinados elementos valorizados no vinho. O resultado é o gosto do Vinotype - a combinação única de sensibilidades e valores que compõem as preferências pessoais do vinho. Os possíveis resultados são: Doce, Hipersensível, Sensível e Tolerante.

Os resultados do questionário online Vinotype mostraram que 9 provadores foram hipersensitivos, 21 sensíveis e 4 tolerantes.

Os provadores avaliaram a intensidade de amargor de 3 soluções de 6-n-propiltiouracilo PROP (0.032, 0.32 e 3.2 mM) numa ordem crescente de concentração. A sensibilidade ao PROP separou os indivíduos em 12 não provadores e 22 provadores.

A determinação do fluxo de saliva determinou que 14 provadores são altos produtores de saliva (>2,4 g/min) enquanto os restantes 20 foram baixos produtores de saliva (<2,4 g/min).

Os participantes avaliaram a intensidade de três soluções de cloreto de sódio (0,01, 0,1 e 1 mM) numa ordem crescente de concentração. Os provadores avaliaram a intensidade do sabor das soluções usando a escala gLMS. O valor da resposta individual à intensidade das concentrações crescentes foi obtido a partir da média geométrica da resposta a cada concentração. Relativamente à sensibilidade ao cloreto de sódio verificou-se que 14 provadores apresentaram alta sensibilidade e os restantes 20 provadores baixa sensibilidade.

Três soluções de ácido tartárico, ácido tânico e sacarose foram preparadas e servidas por ordem crescente de concentração, de cada vez. As concentrações crescentes utilizadas foram de, 0,1, 1 e 10 g/L de ácido tartárico, 0,1, 1 e 2,5 g/L de ácido tânico e 1, 2 e 4 g/L de sacarose, respectivamente.

Os provadores avaliaram a intensidade do sabor das soluções usando a escala gLMS. O valor da resposta individual à intensidade das concentrações crescentes foi obtido a partir da média geométrica da resposta a cada concentração.

Na análise das sensibilidades ao ácido tartárico, ácido tânico e sacarose verificaram-se os seguintes resultados: a) Ácido tartárico, 15 provadores apresentaram alta sensibilidade e 19 provadores apresentaram baixa sensibilidade; b) Ácido tânico, 16 provadores apresentaram alta sensibilidade e 18 provadores apresentaram baixa sensibilidade; c) Sacarose, 14 provadores apresentaram alta sensibilidade e 20 provadores apresentaram baixa sensibilidade.

A preferência pelo gosto doce determinou que 23 provadores não gostaram de uma solução com 205 g/L de sacarose e os restantes 11 gostaram.

O vinho utilizado durante o estudo foi um vinho Macabeo do Instituto Superior de Agronomia produzido no ano de 2016. O vinho utilizado no estudo era seco, de acidez média a baixa e pouco aromático, com notas delicadas de flores silvestres e vegetais. O vinho foi aromatizado com concentrações crescentes de uma solução de aroma. Os compostos de aroma e suas concentrações foram escolhidos com base em pesquisas anteriores de vinhos de Gewurztraminer. A solução de aroma foi composta por butanoato de etilo, 2-metilpropan-1-ol, acetato de isoamilo, 3-metil-butan-1-ol, hexanoato de etilo, 2-fenil etanol, cis-óxido de rosa, acetaldeído, linalol, octanoato de etilo e β-damascenona.

As intensidades de sabor em vinho foram determinadas através de elaboração de cinco soluções de ácido tartárico, ácido tânico e sacarose servidas em ordem aleatória de concentração. As concentrações utilizadas foram de 1 – 0,15g/L; 2 – 0,30g/L; 3 – 0,60g/L; 4 – 1,20g/L; 5 – 2,40g/L de ácido tartárico, 1 – 0,09g/L; 2 – 0,19g/L; 3 – 0,38g/L; 4 – 0,75g/L; 5 – 1,50g/L de ácido tânico e 1 – 6g/L; 2 – 12g/L; 3 – 24g/L; 4 – 48g/L; 5 – 96g/L de sacarose. Os provadores avaliaram a intensidade de cada uma das soluções utilizando uma escala gLMS. A preferência foi determinada através da utilização de uma escala gVAS, que apresenta no seu limite esquerdo a descrição “desgosto extremamente” e no seu limite direito a descrição “gosto extremamente”.

Foram preparadas 4 soluções em vinho branco, aromatizadas com concentrações crescentes de solução de aroma de Gewurztraminer. A primeira solução é de controlo (sem adição de solução aromática) e as restantes com as seguintes concentrações de solução aromáticas 0.5 ml/L, 1 ml/L e 2 ml/L, respectivamente.

Para cada uma das 4 soluções em vinho branco, aromatizadas com concentrações crescentes de solução de aroma os provadores avaliaram a intensidade aromática, intensidade de doçura, intensidade de acidez, intensidade de salgado e de preferência.

A intensidade aromática foi determinada pela medição da distância entre o nariz e o copo à medida que este se aproxima do nariz. Quando o provador sente o aroma do vinho, pára de aproximar o copo e regista a distância do nariz ao copo em centímetros, com a ajuda de uma régua de 20 cm. Quanto mais longe do nariz sentir o aroma, maior a intensidade aromática do vinho. Os provadores tiveram que avaliar a intensidade do aroma de 4 soluções crescentes de vinho branco, uma solução de controlo, sem solução de aroma adicionada, e as outras três com 0,5 ml / L, 1 ml / L e 2 ml / L, respectivamente, antes de avaliar a preferência.

O método utilizado na determinação da intensidade aromática, que consiste na medição da intensidade de aroma através da distância do copo de prova ao nariz (em cm), permitiu provar que, no caso em estudo, a distância do copo de prova ao nariz aumenta de forma crescente da menor solução (testemunha) até à solução com maior concentração de aroma (2 ml/L).

Nos vinhos aromatizados com crescentes concentrações de soluções aromáticas foi demonstrado que a intensidade da doçura está relacionada com a intensidade aromática do vinho, isto é, para um aumento da concentração de solução aromática maior é percepção da doçura pelo painel de prova. As intensidades de acidez e salgado foram constantes face ao aumento de concentração de solução aromática, assim como a preferência. A intensidade aromática foi determinada pela medição da distância entre o nariz e o copo quando o indivíduo sente o aroma. O painel de provadores apresentou dois grupos distintos relativamente à resposta à intensidade aromática. Por um lado, o grupo composto por indivíduos com alta e baixa sensibilidade à intensidade aroma apresentou uma resposta idêntica ($p<0.05$) à doçura e preferência do vinho, por outro lado, outro grupo apresentou baixos valores de intensidade para acidez e salgado.

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1. Introduction

"*For many producers as well as aficionados, wine is an art object, albeit a liquid one. All that attention to detail, striving for individuality, retention of attributes from sun, soil and scion, culminate in the moment it is poured into a glass, swirled, sipped, savored and swallowed. Then it fades into memory. During that brief interlude between the wine's ultimate alpha and omega, the consumer is exposed to a fascinating spectrum of sensations. These may provide clues to the wine's provenance, style, varietal origin, age, complexity, and quality. Although most wines do not require, nor benefit from, intense scrutiny, fine wines do warrant and reward the effort involved. Because the consumer can never know exactly what to expect from a bottle, truncating any of the steps in a formal tasting risks missing one or more of its sensory delights, and obviate relishing in the efforts put into its production*" (Jackson, 2014).

1.1 The multisensory wine perception

The act of drinking involves directly the senses of smell, taste and touch. These senses are simultaneously stimulated and so it is not easy to define how each of them influences wine perception (Small, 2012).

Aroma can be defined as "the property of certain substances, in very small concentrations, to stimulate chemical sense receptors that sample the air or water surrounding an aroma" (Illy and Viani, 2005). According to the American Society for Testing and Materials (ASTM), it is the "perception resulting from stimulating the olfactory receptors; in a broader sense, the term is sometimes used to refer to the combination of sensations resulting from stimulation of the nasal cavity" (ASTM E253-03). International Organization for Standardization (ISO) does not give a unique definition, describing it as "an odour with a pleasant connotation" or "organoleptic attribute perceptible by the olfactory organ via the back of the nose within tasting" (ISO 5496:1992).

Flavor is by far the most debated term and it varies according to the field of research. An early sensory definition was "the sensation realized when a food or a beverage is placed in the oral cavity. It is primarily dependent upon reactions to taste and olfactory receptors to the chemical stimulus. However, some flavors also involve tactile, temperature and pain receptors" (Beidler, 1958). Therefore, flavor is a multi-modal perception deriving from the activity of neurons that respond to inputs from different sensory receptors (Small, 2012). The receptive field for flavor is the mouth, where smell, taste and touch are pooled and transformed into flavor percepts (Small, 2012). Visual and sound clues can also influence the percept flavor (Jackson, 2014).

The gustatory sense produces the sensations of sweet, sour, salty, bitter and savory. Taste is perceived through the oral cavity together with tactile sensations that always co-occur with taste (Small, 2012). The oral cavity also appears to be the source of olfactory stimuli, which are thus mislocalized. This perceptual illusion explains why the confusion between smell and taste is frequent and has been named as “oral referral” (Spence, 2016). This phenomenon is central to the multisensory flavor perception, being dependent on tactile capture of olfaction, the relative timing of olfactory and gustatory stimuli and gustatory capture (Spence, 2016). Oral referral of orthonasal aroma is modulated by taste intensity, while for retronasal odors, it is the congruency between the odor-taste pairing that is the key. The more congruent a particular combination of smell and taste, the more likely the component unisensory stimuli will be bound together as a flavor object (Spence, 2016).

1.1.1 Olfaction

Odor is the sensation perceived by means of the olfactory organ in sniffing certain volatile substances (ISO 5492:2008). Our ability to sense odor is dependent on two, small, seemingly insignificant patches of tissue in the upper recesses of our nasal passages. Volatile compounds reach the olfactory epithelium either directly, via the nostrils (orthonasal), or indirectly from the back of the throat (retronasal). The latter route is especially important in the generation of flavor. The term orthonasal olfaction used for when we inhale, or sniff, while retronasal olfaction occurs when volatiles are pulsed out from the back of the nose while eating and drinking. Orthonasal olfactory cues are key to setting our expectations concerning the sensory and hedonic attributes of food and drink; by contrast, retronasal olfactory cues are central to the experience of flavor (Spence, 2016).

The sense of smell is very complex. Aroma and flavor are chemical senses stimulated by the chemical properties of odor molecules which must reach the olfactory bulb to interact with olfactory cells in the olfactory mucosa. Smells are detected by breathing air that carries odor molecules. Therefore, to smell, molecules must be airborne (i.e., volatile).

The air comes in contact with the tiny smell receptors high in the nasal passages. These receptors send information to smell nerves, then the brain. The specific reaction with the odor molecule is unknown. The sensory term which we term “flavor” is a mingled experience with includes sensations of vision, smell, temperature, pain, pressure and other tactile sensations (i.e. texture). By definition, flavor is based on human judgment. Thus, the study of volatile compounds by GC, HPLC and other physical and chemical means is not “flavor” research.

Factors affecting odor sensitivity include interactions with other senses such as taste and vision/color. In particular, color can lead to the perception of smell when it isn’t present, increased perceptions or distorted perceptions. Odor is subject to adaption in which one odor generally has little effect on perception or dissimilar odors, but interferes with the perception of similar ones. Other factors affecting odor include age, gender, smoking and olfactory disorders (anosmia, hyposmia, hypersomnia and dysomia.).

Generally in wines, esters are responsible for the fruity notes while some lactones and volatile phenols contribute to the woody character. These volatile compounds are present at different concentration levels and proportions, depending on the wines. A previous study showed that when woody character increases, the flavor complexity of wine decreases. Indeed, the intensity of fruity and floral notes was especially reduced. This suggested an interaction, at a perceptual level, between the fruity and woody notes of wine. Thereafter it could be hypothesized that various proportions of the same odorants in a mixture generate various sensory perceptions that may be at the origin of wine aromatic bouquet specificity (Atanasova et al. 2004).

1.1.2 Gustation

The perceptions of taste and mouth-feel are derived from two distinct sets of chemoreceptors. Taste is associated with specialized receptors primarily located in taste buds on the tongue. They generate at least five, distinct, receptor-mediated, gustatory sensations – sweet, umami, bitter, sour, salty (Jackson, 2014).

Taste, according to the International Standard Sensory Analysis Vocabulary (ISO 5492:2008), is defined as sensations perceived by the taste organ when stimulated by certain soluble substances. Taste is closely related to smell. The perception of odor and taste, combined with trigeminal sensations, results in the overall flavor. Flavor influences food acceptance and selection of food intake, and helps us to distinguish potentially harmful compounds. The taste sensation is a very complex process starting at the sensory receptor level and finishing in the central nervous system, where it is combined with information coming from other senses. The sense of taste is a chemical sense due to taste stimuli falling on taste receptors located on the tongue called taste buds.

1.1.2.1 Sweet

Taste cells have G-protein-coupled receptors or GPCRs on their surfaces. When tastants of sweet substances such as sugar goes into the mouth, they bind to the GPCRs, particularly gustducin. This leads to the release of calcium ions (Ca++) and influx of sodium ions (Na+) into the cell, causing it to depolarize and release ATP. The release of ATP generate action potentials in a sensory neuron nearby.

1.1.2.2 Salty

Current research on salt sensation tells us that sodium chloride or table salt stimulates an ion-channel receptor that admits the sodium ions into the cell. When this happens, the cell undergoes depolarization. When the limit or threshold for cell depolarization occurs, action potentials are generated in a neighbouring sensory neuron.

1.1.2.3 Sour

Sour substances, mainly acids, liberate hydrogen ions or protons (H+). These protons are detected by sour receptors. Once detection of H+ occurs, potassium ion channels (K+) closes, leading to cell depolarization. Then, a neurotransmitter called serotonin is released into the synapse with a nearby neuron.

1.1.2.4 Bitter

Just like the sweet sensation, bitter sensation also includes the binding of bitter taste molecules on the GPCRs coupled to the protein gustducin. There are about 25 varying bitter receptors or T2Rs encoded in human genes.

1.1.2.5 Umami

"Umami" is a Japanese word which means "delicious", "yummy", "savory", or "pleasant taste". It is a meaty taste sensation that corresponds to the salts of glutamic acid. Umami became more popular with the use of monosodum glutamate (MSG) as a glavor enhancer in many Asian, particularly Japanese, dishes. The umami tastants bind in GPCRs, and thus, they have a signaling sequence similar to that of the bitter and sweet sensations.

Factors affecting taste sensitivity include age, smoking, viscosity of products, taste disorders (ageusia, non-tasters, hypogeusia, hypergeusia, dysgeusia) and temperature.

1.1.3 Tactile Sensations

Mouth-feel is activated by free nerve endings, and gives rise to the sensations of astringency, dryness, viscosity, heat, coolness, prickling, and pain. Textural perceptions, could be generated by salt crystals or sediment that are generally not present, or should not be present. The only textural aspect associated with wine is generated by the bursting of a sparkling wine's bubbles. Their distribution throughout the oral cavity generates diffuse, poorly localized sensations. In wine, mouth-feel includes the perceptions of astringency, temperature, prickling, body, and burning. They derive from the stimulation of one or more of the (at least) four general categories of trigeminal receptors. These are mechanoreceptors (touch), thermoreceptors (heat and cold), nocireceptors (pain), and proprioreceptors (movement and position) (Jackson, 2014).

1.1.3.1 Astringency

Astringency refers to a complex of puckery, rough, dry, dust-in-the-mouth, occasionally velvety sensations, whose precise molecular origins are still in dispute. Regarding tannins, hydrolysable tannins (gallo- and ellagitannins) and condensed tannins (also known as proanthocyanidins) are the most important polyphenolic compounds present in wines that are able to interact with proteins and, therefore, the most related to astringency perception. However, other wine phenolic compounds, such as flavonols, phenolic acids or anthocyanins, can also play an important role in astringency development (Jackson, 2014).

Anthocyanins can enhance the astringency induced by procyanidins, but do not directly contribute to astringency or bitterness. White wines show less astringency due to their lower phenolic concentrations. When astringency is detected in white wines, it probably arises due to high acidity. Although astringency may be confused with bitterness, both being primarily induced by related compounds, they are distinct sensations. Astringency in wine is normally ascribed to the binding and precipitation of salivary proteins and glycoproteins with phenolic compounds.

1.1.3.2 Burning

Wines high in ethanol content produce a burning mouth-feel, especially noticeable at the back of the throat. Some phenolics also produce a peppery burning sensation, as can high sugar contents. These perceptions probably result from the activation of polymodal nocireceptors on the tongue and palate. These neurons possess vanilloid receptors (TRPV1). They act as an integrator of many noxious stimuli (heat, acids), and complex bio-organics, such as capsaicin found in chili peppers. These receptors can generate either heat or pain sensations. Most sapid substances, when generating intense sensations, stimulate nocireceptors (Jackson, 2014).

1.1.3.3 Temperature

The cool mouth-feel, produced by chilled sparkling or dry white wine, adds an element of interest and pleasure to these wines of subtle flavor. Cool temperatures also help extend the duration of effervescence shown by sparkling wines. In contrast, red wines typically are served at room temperature. This preference may be based on reducing the wine's perceived bitterness and astringency, and increasing the volatility of its aromatics. Nevertheless, the preferred serving temperature of wine may reflect custom, as much as any other factor. This is suggested by the apparent nineteenth-century predilection for drinking red bordeaux cold, although it may also relate to the wines at that time resembling more rosés that red wines. The old expression for bordeaux wines was claret, from vin claret, referring to yellowish to light red wines (Jackson, 2014).

1.1.3.4 Prickling

Bubbles bursting in the mouth produce a prickling, tingling, occasionally burning/painful sensation. These are partially associated with stimulation of trigeminal nerve endings. However, there appears to be a second aspect to the sensation. An enzyme, carbonic anhydrase, present on gustatory cells, almost instantaneously converts carbon dioxide and water to bicarbonate and hydrogen ions (Jackson, 2014).

The hydrogen ions may directly activate acid-sensing receptors, contributing to the sensation generated by CO2. Alternately, conformation changes in membrane-bound carbonic anhydrase may induce activation of acid receptors. These sensations are primarily elicited by wines containing more than 3–5‰ carbon dioxide. They appear partially related to bubble size and temperature, and are more pronounced at cold temperatures. Carbon dioxide can also modify the perception of sapid compounds, enhancing sourness and suppressing sweetness, and significantly increase the perception of cold in the mouth.

1.1.3.5 Body (Weight)

Although 'body' is a desirable aspect in most wines, the precise origin of this perception remains largely a mystery. Sweetness often roughly correlates with a sensation of fullness in the mouth, possibly due to its influence on enhancing the perceived intensity of aromatics. Other tastants appear not to have a similar effect, including alcohol. In contrast, aromatics have little or inconsistent influence on the perception of tastants. Glycerol can increase the perception of body, but only at concentrations found in some very sweet wines. The viscosity range characterizing most table wines seems, by itself, insufficient to explain perceived differences in body. Nonetheless, other constituents appear to induce perceived differences in body. In the white wines they studied, body seemed correlated with a combination of factors, including physical viscosity, osmotic potential, total extract, as well as lactic acid and magnesium contents. Aspects, such as acidity, appear to reduce the perception of body. Less recognized is the importance of grape and yeast polysaccharides. Both the main yeast polysaccharides (mannoproteins) and principal grape polysaccharides (arabinogalactanproteins and rhamnogalacturonans) increase the perception of body (fullness). Regrettably, the phenolic composition is so complex, and the exact meaning of body as illusive, that obtaining any precision in predicting their influence is nigh impossible. Another element in the perception of body almost undoubtedly involves aspects of wine fragrance, notably its intensity (Jackson, 2014).

1.1.3.6 Metallic

According to Jackson a metallic sensation is occasionally detected in dry white wines, especially sparkling wines. Its origin has not been established. It could be induced by iron and copper ions. However, concentrations required to directly produce a metallic taste are normally well above those found in wine (>20 and 2mg/liter, respectively). Smaller quantities may, however, be involved in catalyzing fatty acid oxidation.

When oxidized, lipid carbonyl by-products can generate metallic sensations, for example, oct-1-en3-one. Several reduced sulfur compounds also have a metallic attribute, for example, 2-methyltetrahydrothiophen-3-one and ethyl-3-methylthiopropionate. That metallic sensations typically disappear when the nostrils are pinched, only to reappear when they are reopened, are, in reality, misinterpreted, retronasal, olfactory sensations (Jackson, 2014).

1.2 The sensory complexity of wine

1.2.1 Diversity of wine aroma and flavor

Aroma is one of the most important quality attributes for wine and many other alcoholic beverages. However, the chemical composition of most alcoholic beverages is so complex that it has always been a challenge for scientists to fully understand their flavor chemistry (Qian et al., 2012).

Aroma compounds, as a result of their pronounced effect on the sensory organs, play a definitive role in the quality of the food and luxury products. As in the case with most food products, the aroma or "bouquet" of a wine is influenced by the action of several hundred different compounds. When dealing with wine aroma, a distinction is made among—(1) primary or grape aroma: aroma compounds as they occur in the undamaged plant cells of the grape; (2) secondary grape aroma: aroma compounds formed during the processing of the grapes (crushing, pressing, skin contact) and by chemical, enzymatic-chemical, and thermal reactions in grape must; (3) fermentation bouquet: aroma compounds formed during the alcoholic fermentation; (4) maturation bouquet: caused by chemical reactions during maturation of the wine (Rapp et al., 1995).

According to Ferreira, aroma compounds in wine are classified according to the role they can play in wine.

- Impact or highly active compounds, are the compounds which can effectively transmit their specific (impact) or primary (highly active) aroma nuance to a given wine without the need of the support of more aroma chemicals. An example is linalool.
- Impact groups of compounds. These are families of compounds usually having similar chemical structures (chemical homologous series) and with quite close odour properties and that can impart to the aroma of a wine the specific notes of the family. An example is the γ-lactones.
- Subtle compounds or families. These are the compounds or groups of compounds which fail in transmitting their specific aroma nuances to the wine, but contribute decisively to the development in wine of some secondary-generic aroma nuance (for instance fruity, sweet) always with the necessary support of other chemicals bearing a similarity in such odour notes. Compounds in categories 1 and 2 in insufficient concentration, or even if present at high enough concentration, they co-occur with many other powerful odourants (such as happens in complex wines), may fall into this category.
- Compounds forming the base of wine aroma. These are the compounds, present in all wines at concentrations above their corresponding odour thresholds which, however, are no longer perceived as single entities because their aromas are fully integrated to form the complex concept of wine aroma. Within this group different roles can be found: a. aroma enhancers; and b. aroma depressors.
- Off-flavours. These are the compounds whose presence brings about a decrease in the general aroma quality of wine.

Wine aromas are very diverse. When we talk about wine aromas we are talking about a number of different things. While the aromas of any one wine are strongly linked to the particular grape variety/ies that made the wine, they are also influenced by where the grapes were grown, by how the wine was made (such as particular winemaking and maturation techniques) and, by bottle age. Different grapes have different primary aromas. The same grape grown in a cooler climate will have different aromas when grown in a warmer climate. For example, Chardonnay grown in a cool climate like Chablis, will have prominent green apple and citrus aromas. Chardonnay grown in a moderately warm climate such as the Macon will smell more like melon and grapefruit, while Chardonnay grown in a warm climate will show more pineapple and tropical fruit aromas. Grape aromas can be fruity and/or floral. Many white varieties such as Riesling and Viognier have very definite floral notes. Fruit aromas most associated with white wines include citrus, orchard, stone and tropical fruit. Red fruit aromas span the gamut of black and red fruits, all sorts of plums, berries and cherries. Depending on ripeness the aromas can be like freshly picked fruit, jammy, baked or even raisined or dried when ultra ripe. Beyond fruity, wine aromas can be mineral, spicy, vegetable, herbal or herbaceous. While some of these aromas can come from the primary grape, they can also come from the specific terroir, where the grapes were grown. Herbal aromas can be fresh or dried and include tarragon, mint, eucalyptus as well as the famous Garrigue aroma associated with the wines of Châteauneuf du Papes. Herbaceous aromas include grassy or asparagus notes so often found in Sauvignon Blanc. Mineral aromas can be flinty, stony, earthy or tarry. Vegetable aromas include green or black olive (think cool climate Syrah) as well as all sorts of salad, peas and beans. Finally, spicy aromas can be inherent to the grape such as black pepper in Syrah, white pepper in Gruner Veltliner or they can come from oak (Reynolds, 2010).

As well as adding spice, oak can add all sorts of wonderful aromas to a wine including cedar, toast, char, smoke, clove, licorice, baking spices, vanilla, coconut or vanilla.

Cool temperature fermentations tend to preserve and even enhance the primary fruit aromas of the grape, while warmer fermentations tend to produce wines that are more driven by structure than primary fruit. Similarly wines fermented in stainless steel tanks are typically fruitier than those vinified in cask. Techniques such as Malolactic Fermentation (MLF), which converts the harsher malic acid in a wine into a softer lactic acid can add creamy, buttery aromas to a wine.

As a wine ages either in tank, wood or in bottle it undergoes lots of internal chemical reactions. Compounds in the wine breakdown and react with each other to form new compounds and new aromas. Such aromas include leather, cigar box, truffle or mushroom, fusel/petrol, brioche/cereal or honey aromas.

Off-aromas or faults can also be present in wines. These are the aromas that we do not want to find in our wine. Sometimes a teeny weeny hint of certain ones is desirable and actually adds complexity to a wine, but it is a thin tightrope and a dominant force of any of them is undeniably a fault. Such aromas include overly oxidative aromas, cork taint (TCA), vinegar, nail polish remover, rotten cabbage, sulphur, stinky barnyard or smelly sweat.

A normal table wine contains several hundreds of volatile compounds, but most of them are at concentrations well below the threshold, which means that they are not really relevant in the perception of the sensory attributes of the wine. The number of odour molecules really active in a normal wine lies between 20 and 40, and the total number of odour molecules that can be really active in the different kinds (without odour problems) of wines is around 70.

The base aroma of wine is formed by chemical compounds, mainly ethanol, diacetyl, acetaldehyde, fusel alcohols, organic acids, isoacids, organic acid ethyl esters, fusel alcohol acetates and ethyl esters of isoacids (Reynolds, 2010).

The complexity of wine aroma is in accordance with its chemical complexity. As happens in complex perfumes, and far from the artificially flavored products, wine aroma is the result of complex interactions between many odour chemicals (Reynolds, 2010).

1.2.2 Wine Flavor

Flavor refers to the taste of a wine in your mouth. As well as reflecting the aromas absorbed retro-nasally, the overall flavor of a wine is also influenced by the wine's acidity, sweetness, alcohol level, tannins, astringency, body and in sparkling wines by its fizziness, as these components can accentuate or neutralize the flavors.

All grapes contain flavor compounds, some more than others. Grapes also contain flavorless compounds, which are activated through different chemical reactions that occur during winemaking and wine maturation, thereby releasing additional flavors into the wine. This is why the flavor of a wine is more complex than the flavor of grape juice, and also helps explain why the flavors of a mature wine are more complex than those of a young wine.

As with aromas, wine flavors can be categorized as fruity, floral, spicy, mineral, vegetal or oaky. Fruit flavors can be fresh and lively or jammy, baked or even raisined. Apart from identifying types of flavors we also consider the intensity of these flavors. More intense, concentrated flavors are typically a sign of a better wine, due perhaps to riper grapes, smaller-berries, a stricter selection of only the best grapes or longer maceration and/or extraction time during vinification.

Flavors also contribute to an overall taste sensation. Wine flavors can be bold and forward or subtle and restrained. They can be quite precise and focused or somewhat muddled and vague. They can be generous or lean, tight-knit or loose-knit. In short, they flavors be well defined or poorly defined.

As with aromas, wine flavors change as a wine matures. In a young wine, the youthful primary fruit flavors prevail. With age, these are replaced by more developed flavors of leather, earth, spice, truffle and game in red wines, or honey, nutty, fusel and toasty brioche flavors in whites.

Depending on the amount, ripeness and texture, tannin can add unctuousness and plump out a wine's flavors, or it can make a wine taste astringent and bitter. The flavors of young very tannic wines, particularly top Bordeaux or Barolo wines can be hard to appreciate until the tannins start to resolve and integrate.

Acidity brightens a wine's flavors and makes them stand out. Alcohol creates a feeling of warmth. When in balance it adds to the overall taste sensation. When high, it can give a perception of sweetness to a wine, and when too high it gives a burning sensation, and cut short wine flavor.

Finally, bubbles accentuate flavors in a wine. Tiny persistent bubbles enhance flavor and add elegance, whilst, larger coarser bubbles mask flavor with froth.

1.2.3 Taste-aroma interactions

The sensory character of a food results from the integrated perception of the multiple stimuli elicited by its chemical and physical properties. I would be inappropriate to try to understand each single perception separately as the perception of each stimulus can be affected by the presence in the food of other stimuli, assessed by other senses. Food chemists, sensory analysts and psychophysicists have tried for decades to understand the origin and mechanism of multisensory perception of flavor. In particular, retronasal aroma perception can be modulated by the presence of sapid compounds although these do not stimulate olfactory receptors. How the perception of aroma interacts with the perception of sweet taste has notably been the subject of many studies. Different aroma compounds have been found to enhance sweetness perception. Reciprocally, the addition of sucrose has also been found to increase perceived aroma intensity in model solutions (Arvisenet, et al. 2015).

The mechanisms proposed to explain the mutual influence of aroma and taste when perceived together can occur at physicochemical, physiological or psychological levels.

1. *Physico-chemical interactions*: can occur between aroma and taste compounds in the matrix, changing the concentration of the stimulus before it activates the receptors. Such interactions between sweet compounds and odorant volatile compounds can induce either the retention or the release of the volatile compounds, depending on the nature of the volatile and saccharide molecules.
2. *Neurophysiological level*: Unlike taste-taste and odor-odor interactions, it seems utterly improbable that taste-aroma interactions would occur at the level of the olfactory or gustative receptors. However, the olfactory and gustatory signals have been shown to converge in the same areas of the orbitofrontal cortex. The activation of certain brain areas by an odor-taste pair is correlated with the congruence of the two stimuli.
3. *Psychological interactions*: Some authors consider flavor as a “distinct sense” cognitively constructed from separate sensory systems, primarily olfaction and gustation. A prior experience of the occurrence of a gustative and an olfactory stimulus in the mouth results in the acquisition of a flavor memory, which can later be reactivated when one of its components is experienced alone (Arvisenet, et al. 2015).

It has been widely accepted that interactions can, and do, occur within stimuli (aroma, taste, appearance or mouth feel). These interactions may result from physicochemical interactions (structure and binding effects) in the product itself, interactions at the receptor level or cognitive interactions. Many studies have shown that odors can suppress, enhance or have no effect on tastes.

According to the work of Saenz-Navajas et al. (2010) the sweetness of dry wine is closely related to fruity aroma, and that, as sweetness most likely affects the perceptions of astringency and bitterness, these two last percepts are also inversely related to fruity aroma.

1.2.4 Temporal evolution of taste and mouth-feel sensations

To distinguish between the various taste and mouthfeel sensations, tasters often concentrate sequentially on the expression, intensity and duration of each attribute. Their temporal response curve is a useful feature in identifying taste sensations. The perceived localization of the sensations in the mouth and on the tongue further aids in affirming taste characterization. Balance is a summary perception, derived from the interaction of sapid and mouth-feel sensations (Jackson, 2014).

Sweetness is usually the most rapidly detected taste attribute. Sensitivity to sweetness occurs optimally at the tip of the tongue. It also tends to be the first taste sensation to show adaptation. The intensity of its perception is reduced in relation to a wine’s acidic or tannic content (Jackson, 2014).

Sourness is also detected rapidly. The rate of adaptation to sourness may be slower, and often generating a lingering aftertaste when pronounced. Acid detection is commonly strongest along the sides of the tongue. This varies considerably among individuals, with some people detecting sourness more distinctly on the back of the lips, or inside of the cheeks. Strongly acidic wines can induce astringency, giving the teeth a rough feel. Both the sour and astringent aspects of markedly acidic wine may be decreased by sweetness and perceptible viscosity (Jackson, 2014).

The detection of bitterness usually follows any perception of sweetness or sourness. It typically takes several seconds to express. Peak intensity may not be reached for 10–15s. After expectoration, the sensation gradually diminishes, but may linger for several minutes. Most bitter-tasting compounds in wine, primarily phenolics, are perceived at the back-central portion of the tongue. In contrast, bitter alkaloids are perceived primarily on the soft palate, and at the front of the tongue. The bitterness of a wine is more difficult to assess accurately when the wine is also distinctly astringent. High levels of astringency may partially mask the perception of bitterness. High sugar contents also reduce the perception of bitterness, a phenomenon well known to those who cannot suffer coffee black (Jackson, 2014).

Following Jackson (2014) astringency is often the last sensation detected. It can take 15 or more seconds for its perceived intensity to develop fully. After expectoration, the sensation slowly declines over a period of several minutes. Astringency is poorly localized, because of the dispersed distribution of free nerve endings throughout the mouth. Because both the perceived intensity and duration of astringency increase with repeat samplings, some judges recommend that astringency be assessed with the first taste. This would give a perception more closely approximating the astringency detected on consumption with food. Others consider that the assessment of astringency should occur only after several samplings, when the mollifying effects of saliva have diminished. Both have justifiable rationales, depending on the intention of the assessment.

The increase in perceived astringency, that can occur when tasting a series of wines, could seriously affect the validity of a wine's assessment. This is especially true with red wines, for which the first wine in a series often appears the smoothest. Variability in alcohol content can also result in sequence error effects. A similar situation could occur in a series of dry white wines, as well as making a sweeter wine appear overly sweet. These influences are sufficiently well known that tastings are organized to avoid the joint sampling of wines of markedly different character. However, design errors can still have significant effects on well-conceived comparative tastings. The effect of sequence error may be partially offset, in group tasting, by arranging that all tasters sample the wines in random order. In addition, lingering taste effects can be minimized by assuring that adequate palate cleansing occurs between samples (Jackson, 2014).

Although the number of in-mouth sensations is limited, they are particularly important to consumer acceptance. Unlike professionals, consumers seldom dote on the wine's fragrance. Thus, in-mouth sensations are far more important to their overall impression of wines. Nevertheless, even for connoisseurs, one of the ultimate tests of greatness is the holistic impression of mouth-feel and balance. These are phenomena principally associated with joint gustatory and tactile sensations. Producing a wine with a fine, complex, and interesting fragrance is often a significant challenge for the winemaker. Assuring that the wine also possesses a rich, full and balanced in-mouth sensation is the ultimate achievement (Jackson, 2014).

1.3 Sensory Analysis

1.3.1 Sensory analysis evaluation methods

Sensory evaluation methods may be divided into two broad classes: affective and analytical methods (IFT, 1981) (Fig.1.1). The most common analytical methods of sensory evaluation used in the wine industry are discrimination (or difference) and descriptive methods. Discrimination tests can be used to determine if products are different, if a given wine characteristic is different among samples, or if one product has more of a selected characteristic than another. Experienced panelists can complete discrimination tests.

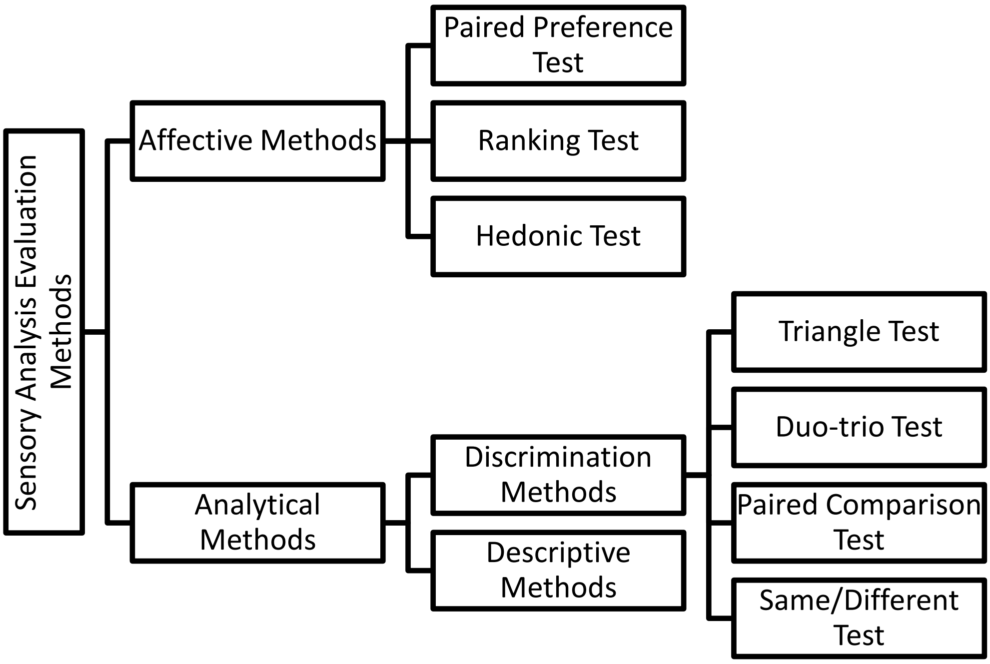

Figure 1.1. Sensory Analysis Evaluation Methods.

1.3.1.1 Discrimination (Difference) Tests

Difference testing is used to determine if different winemaking processing techniques or operations have a sensory impact. As such, difference testing methods generally provide the winemaker with the practical information needed. They are the most feasible for use in a winery environment, and are simple and robust.

The most common for use in the wine industry are the triangle difference test and the duo-trio difference test:

- triangle: “Is a particular lot made with rot-compromised fruit different from other lots?”
- duo-trio: “Is there a sensory difference among wines fermented with different yeasts?”
- paired comparison: “Does the high VA in this wine impact it sensorially?”

Triangle tests are useful as a multi-purpose test. The taster is required to select the sample which is different. Triangle tests are often preferred, as they require fewer tasters, and there is a greater likelihood that a result will be genuine and not due to a chance effect.

Duo-trio tests are sometimes used instead of triangle tests to compare unknown differences between wines. Tasters are presented with a reference wine, and then two test wines; one wine is the same as the reference, and the other is the wine to be tested. Evaluators are asked to identify the sample that is the same as the reference wine.

Paired comparison tests can be used when there is a known difference in chemical composition of the wines (a simple difference test), which requires a sensory assessment. For example, a higher VA is present. But does the wine have a spoilage character? Is the wine more volatile?

A same/different test is similar to the paired comparison test, however, it is used when the difference between two wines is unknown. Evaluators are asked to identify whether they think the two samples presented are the same or different. These tests are easy to set up, but more panel members are required, and evaluators must perform the test at least twice, receiving a different randomized serving order each time (Zoecklein, 1999).

1.3.1.2 Descriptive Tests

Frequently, it is important to know how a wine changes with a new vineyard site, how intense a characteristic is, etc. Discrimination testing, which is easy to use, easy to interpret, and easy for panelists to complete, is initially used to determine that a difference does exist. Such methods cannot provide information about the description of those differences, though.

Descriptive evaluation methods are more difficult to complete and interpret, but provide much more information. They provide a quantitative measure of wine characteristics that allows for comparison of intensity between products, and a means of interpretation of these results. Examples of descriptive test methods include quantitative descriptive analysis (QDA®), flavor profile analysis, timeintensity descriptive analysis, and free-choice profiling (Hootman, 1992; Meilgaard et al., 1991; Stone and Sidel, 1985). QDA® is frequently used because it requires less training time than several of the other methods.

1.3.1.3 Affective methods

Commonly-used affective methods include a paired preference test, a preference ranking test, and the hedonic test method (Meilgaard et al., 1991; Stone and Sidel, 1985). The test method must be simple and easy to understand, so the consumers making up the panel will know how to respond.

1. *Paired Preference Test:* Once a significant difference has been established between two wines, a preference test can be performed. This is useful in determining which wine blend or which yeast fermentation is preferred, for example.

2. *Ranking Test:* If more than two samples are evaluated, a preference ranking test may be completed. Usually three to five samples are the most that can be efficiently ranked by a consumer. This test asks the consumer to order the samples based on preference, with a ranking of “1” meaning most preferred.
3. *Hedonic Test:* The hedonic scale may be used to determine degree of acceptability of one or more products. This scale is a category-type scale with an odd number (five to nine) categories ranging from “dislike extremely” to “like extremely.” A neutral midpoint (neither like nor dislike) is included. Consumers rate the product on the scale based on their response.

1.3.2 Limitations of sensory analysis evaluation

Control of the human aspect of sensory evaluation is one of the more difficult factors of sensory evaluation. This may be accomplished best by carefully selecting the people that will be participating in the test. Important qualities in a sensory panelist include availability, dependability, interest, objectivity, stability, and acute senses of smell and taste (Hootman, 1992; Meilgaard et al., 1991; Stone and Sidel, 1985).

Unlike instruments, human judgements can easily be affected by psychological or physiological factors. The sensory professional must be aware of these factors and ensure that the chosen procedure and experimental design eliminate or reduce such bias (Kemp et al., 2009).

Table 1.1. Human factors affecting sensory analysis (Kemp et al., 2009).

Psychological factors	Physiological factors
• Expectation error; • Suggestion effect; • Distraction error; • Stimulus and logical error; • Halo effect and proximity error; • Attribute dumping; • Habituation; • Order effect; • Contrast and convergence effects; • Central tendency error; • Motivation error.	• Adaptation; • Perceptual interactions between stimuli; • Physical condition.

When working with assessors from different cultures or geographical location, the sensory professional needs to be aware of the impact that cultural effects can have on sensory data. In some cultures, particular product codes may have significant connotations.

In addition, wine with more than 1000 identified sensory active compounds, has several particular limitations. Our limited understanding lies with the features below, with the multifaceted interactions that occur among the numerous chemical components, and the effect of these interactions on perception:

- Adaptation
- Individual variability
- Carry-over effects
- Difficulty in distinguishing some sensory components
- Non-standardized language
- Expectations/bias
- Differences between “expert” opinion and consumer preferences

1.4 Taster segmentation

The understanding of individual differences in orosensation is of great interest for the wine industry, these differences may represent opportunities for developing new products based on the different responses of individuals.

Special attention should be given when it comes to create consumer/taster segments, as through this procedure we receive information about taste sensitivity and preferences as well (Francis et al., 2015). The most common distinctions are based on different categories linked with demographic, physiological, psychological and taste sensitivities. The segmentation can be achieved usually by simple demographic questionnaires (e.g. with questions aiming to know the gender, age, origin, educational and cultural background etc.) as well as by tests and measurements of the taste functions. However, the most important factor in perception of oral stimuli is genetic variation (Pickering et al., 2008).

1.4.1 Vinotype

The vinotype test is an online wine personalization test (www.vinotype.com) which is principally based on the preferences of the individuals, launched in 2011 (Hanni, 2012). The developer of the vinotype test was Tim Hanni, an American Master of Wine, whose objective was to help consumers find out more about their own preferences. Hanni (2012) takes a phenotypic approach, which demonstrates that all organisms can be categorized into phenotypes, that in the case of individuals, the phenotype is the composite of the individual's observed properties, characteristics and traits (Borchgrevink and Sherwin, 2017). In sum, the phenotypic approach suggests that individuals develop (behavioral, food, entertainment) preferences over time based on their experiences and interaction with their broader environment (Borchgrevink and Sherwin, 2017). Adapting the phenotypic approach to the world of wine and wine preference, Hanni (2012) proposes the use of vinotype, defined as "The set of observable characteristics of a wine-imbibing individual resulting from the interaction of its genotypic sensory sensitivities in a wine-related environment".

The Vinotype assessment consists of various questions that determine the sensory sensitivities and tolerances combined with questions that determine certain elements the taster values about wine. The result is the taster Vinotype – the unique combination of sensitivities and values that comprise wine personal preferences. The possible four results are: Sweet, Hypersensitive, Sensitive and Tolerant.

1.4.2 PROP

According to Tepper (2001), the ability to taste the bitter thiourea compound phenylthiocarbamide (PTC) as well as 6-n-propylthiouracil (PROP) is an inherited characteristic shared by approximately 70% of the US adult Caucasian population, the so called PROP medium tasters and supertasters. The remaining 30% of the population receive PROP as weak or tasteless and they are called nontasters (Tepper et al., 2001). Thioureas contain the chemical moiety N-C=S, which is responsible for its bitter taste (Bartoshuk et al., 1994). It is shown through past studies that PROP tasters (medium tasters and supertasters) generally perceive greater intensity than the nontasters, from a wide variety of compounds, such as caffeine, quinine, benzyl alcohol and many others (Tepper et al., 2001). Prop tasters are also known to show greater sensitivity to oral irritation from capsaicin, cinnamaldehyde and benzyl alcohol (Prescott et al., 2000). The ability to taste this compound is more common in women than in men (Whissell-Buechy and Wills 1989); therefore, women are supertasters more frequently and have more fungiform papillae and more taste buds (Bartoshuk et al. 1994). Also, according to Whissell-Buechy and Wills (1989) this ability is present in young children, declining slowly with age.

The PROP sensitivity evaluation procedure includes a tasting with 3 glasses with 20 ml of water solutions displayed in increasing order of concentration of the compound (6-n-propylthiouracil), 0.032 mM, 0.32 mM and 3.2 mM. The procedure is simple, requesting from the taster to evaluate in terms of intensity perceived, the bitter sensation of each concentration in a 100 mm general Labeled Magnitude Scale (gLMS) and are following classified through the score given to the 0.32 mM solution (Non-taster ≤ 15.5 mm; 15.5 < Taster < 51 mm; Super-taster ≥ 51 mm) (Pickering et al., 2016).

1.4.3 Saliva Flow rate

Saliva is the first physiological discharge induced by ingestion of foods or beverages and its reaction is considered essential in the oral cavity as well as in taste perception (Stokes, 2013). It can affect significantly the perception of taste through titration, dilution and precipitation of stimuli. As it is expected, individuals vary a lot in their salivary flow rates, but what is rather interesting is that there are significant differences in the concentrations of the salivary constituents in the same individual, under different circumstances (Matsuo, 2000). The saliva flow rate can be determined with the stimulation of citric acid (Ishikawa and Noble, 1995). The principles of this method implement that the taster ingests 10 mL of citric acid (with a 4 g/L concentration) and after 10 seconds gathers the expectorated saliva into a cup. The procedure is complete when the saliva produced in one minute is being weighted (Smith et al., 1996), dividing the tasters into low or high producers, using as a cut-off the average saliva weight obtained by the sum of the participants.

1.4.4 Sweet liking

Despite the fact that sweetness is generally a desirable taste, consumers can be divided into two groups, sweet likers and dislikers, according to their hedonic responses and preferences to sucrose solutions (Methven et al., 2016). As humans have an innate tendency for liking sweet flavors, the term “sweet dislikers” is somewhat inaccurate. SD according to Methven et al. (2016), are unlikely to dislike sweetness in totality, but slightly prefer moderate sweetness levels to high sweetness ones.

One approach to evaluate the differences among the degree of tolerance for sweetness, between SL and SD is to measure the point at which food or beverage (in this case wine) is rejected when a quality (in this case sweetness) is being increased (Methven et al., 2016). Such points are known as “Rejection thresholds” (RjT) and they have been previously determined for tastes and flavors that are claimed to have a strong impact on acceptability (Methven et al., 2016).

The evaluation of sweet liking is commonly demonstrated by simple tests that include liking of sucrose solutions using visual analog scales (VAS), to establish SL and SD classifications. VAS is the most common pain scale, being used worldwide for quantification of several chronical painful diseases (Sinha et al., 2017). VAS can be presented in a number of ways, including: scales with a middle point, graduations or numbers (numerical rating scales), meter-shaped scales (curvilinear analogue scales), "box-scales" consisting of circles equidistant from each other (one of which the subject has to mark), and scales with descriptive terms at intervals along a line (graphic rating scales or Likert scales) (Scott & Huskisson, 1976). In general, VAS scales are considered a reliable instrument for more valid and exact measurements than other types of scales, they are more sensitive to small changes and take less than 1 minute to complete, however, assessment is clearly highly subjective and they cannot be administered verbally or by phone as they are used as a paper and pencil measure.

1.5 Objectives of the study

The research performed in this work was aimed at the exploration of aroma-taste evaluations in white wine and respective appreciation. This research was based on the training of a group of tasters which was subjected to segmentation according to gender, smoking habits, vinotype, 6-n-propylthiouracil (PROP) status, saliva flow, sodium chloride sensitivity, tartaric acid sensitivity, tannic acid sensitivity and sweet liking. The effort on taster characterization was also directed to the sensitivity to tastes and mouth-feel sensations in order to understand the influence on wine preference.

Although aroma intensity is commonly used in sensory analysis, there is no obvious method to determine it in wine. As an example, Sáenz-Navajas et al. (2010) were not successful in obtaining consistent assessments of aromatic intensity and did not use this parameter in their studies. Therefore, one of the objectives of this study was to develop an objective and clear method to rate the aroma intensity of a wine.

The overall aim of this study was to obtain a measurement of the effect of the volatile composition of white wine on some in-mouth sensory attributes and basic tastes, such as sweet, acid and salty as well as the effect on wine preference. In particular the objectives of the study were:

- To characterise individual sensitivity to basic tastes;
- To develop a method to rate aroma intensity of a white wine;
- To evaluate the effect of increasing fruity aromatic intensity in dry white wine on taste and appreciation;
- To evaluate the effect of taster characteristics on sensory evaluation and preference of dry white wine.

2. Material and Methods

2.1 Taster Selection and training

The tasting panel was mainly selected among the students of the Master of Viticulture and Enology of Instituto Superior de Agronomia (2016/2017). First and second year students were the main targets of the work. The selection has been concluded in order to find the subjects with the best knowledge and sensitivity about the main descriptors of the mouthfeel: acidity, saltiness, sweetness and bitterness with the purpose to have a group of trustable people in the results and trained to perceive differences. Thirty-four subjects (21 females and 13 males, between 19 and 40 years (average 24.6±5.2) were selected. All sessions took place in the laboratory of Microbiology of ISA and lasted approximately four months, from February to May, applying from one to three different tests each week, depending on time flexibility and materials.

The goal was to find out subjects that consume usually wine at least once a week and were able to distinguish the samples submitted. They were prepared highlighting the main mouth-feel perceptions.

Training began by the evaluation of prototypical tastes (sweet, acid, salt, bitter) and astringency. Several tests were done to select the tasters. The objective of these tests was to determine if the tasters were able to detect the simple tastes. In addition, adaptation to scale utilization was performed by rating several sensations experienced at least once in their life, concerning pain, tastes, and senses (Annex 1.a).

2.2 Taster characterization

2.2.1 Questionnaires

Participants were asked to complete a brief questionnaire that collected basic demographic data (age, gender, nationality, education background). Their wine knowledge was obtained by endorsing the following items: *I don’t drink wine; beginner; intermediate; very high* (Annex 1.b).

2.2.2 Vinotype

Vinotype is an online test (www.myvinotype.com) based on the individual’s wine preferences (Hanni, 2012). It assesses individual taste sensitivities and tolerances and helps the consumers to learn more about their own preferences. The vinotype is the sum of physiological and psychological factors that determine wine preferences and values. The procedure is quite simple, containing short questions that will give the final characterization of the applicant. The possible four results are: Sweet, Hypersensitive, Sensitive and Tolerant (Annex 1.c).

2.2.3 PROP Status and Sodium Chloride

6-n-Propylthiouracil (PROP) status was assessed in duplicate during two 15 minutes sessions in two different days. Participants rated the bitterness intensity of three PROP (Sigma, St. Louis, USA) solutions (0.032, 0.32, and 3.2 mM) in a increasing order of concentration. Individuals were given 20 ml of solution in each glass and instructed to move the sample in the mouth, for 10 seconds, covering all the mouth surfaces and wait for the sensation intensity to peak (10-15 s) and to expel the sample. After 10 to 15 seconds they rated the intensity of the sensation by drawing a mark on a gLMS Scale. The gLMS Scale uses a “barely detectable” on the bottom (0 mm) and a “strongest imaginable” (100 mm) on the top (Bartoshuk 2000) (Annex 1.d).

To help assess the PROP Status another tasting was performed. Participants rated the intensity of three sodium chloride solutions (0.01, 0.1, and 1 mM) in a increasing order of concentration. The procedure was the same used for the PROP solutions.

Tasters were classified as non-tasters and tasters based in the bitterness rating to the 0.32 mM PROP solution using the gLMS Scale (non-taster: ≤ 15.5; taster: ≥ 15,5 and < 51; super tasters ≥ 51; Tepper et al., 2001).

Subjects were trained in the use of the general labeled magnitude scale (gLMS) following published standard procedures (Bartoshuk 2000; Green et al. 1993, 1996) that involved culturally appropriate remembered or imagined sensations. The gLMS is a psychophysical tool that yields high quality, ratio level data (Bartoshuk 2000). It requires subjects to rate their perceived intensity of a given stimulus along a line scale with adjectives at empirically derived intervals. The 100 point scale comprises the following adjectives: no sensation= 0, barely detectable=1.5, weak=6, moderate=17, strong=35, very strong=52, and the strongest imaginable sensation of any kind=100 (Bartoshuk, 2000). The scale presented to subjects shows only the adjectives, not the corresponding numbers. The score, in cm, for each of the intensity measures was manually obtained with a ruler.

2.2.4 Saliva flow

The participants were asked to taste a sample of 0.2 mM citric acid, hold it for 10-15 seconds then spit it out and wait for another 10 seconds for the saliva sample to be gathered in a plastic cup. By weighing the samples given, we were able to determine the saliva flow following the procedure described by Smith et al. (1996). The average saliva weight will be used as a cut-off, to divide the panel according to their saliva production, high producers if total amount of saliva produced was higher than it and low producers if the saliva flow was less than the amount referred above (Annex 1. b).

2.2.5 Taste and sensation sensitivity

Three solutions of tartaric acid, tannic acid and sucrose were served on increasing concentrations each time. The increasing concentrations used were 0.1, 1 and 10 g/L for tartaric acid, 0.1, 1 and 2.5 g/L for tannic acid, 1, 2 and 4 g/L for sucrose. The participants were asked to evaluate the taste intensity of the solutions by using the gLMS scale. The value of individual response to the intensity of increasing concentrations was obtained from the geometric mean of the response to each concentration. Thus the values below the cut-off were classified as low-response and the values considered above were considered as high-response (Annex 1.d).

2.2.6 Sweet liking status

The subjects were assessed regarding their sweet liking status: liking of sucrose solutions (205 g/L) using visual analogue scales (VAS) to establish SL and SD classification. The VAS (Visual analogue scale) scale used for the sweet liker test (150 mm) was marked with a neutral point at half scale length and had end-anchors from ‘‘Dislike Extremely” to ‘‘Like Extremely” (Methven et al., 2016, Asao et al., 2015) (Annex 2.f).

2.3 Determination of taste and aroma intensity in white wine

2.3.1 Determination of taste intensities and liking

Taste intensities were determined by five solutions of tartaric acid, tannic acid and sucrose were served on random order of concentrations each time. The concentrations used were 0.15g/L; 0.30g/L; 0.60g/L; 1.20g/L; 2.40g/L of tartaric acid; 0.09g/L; 0.19g/L; 0.38g/L; 0.75g/L; 1.50g/L of tannic acid and 6g/L; 12g/L; 24g/L; 48g/L; 96g/L of sucrose. The participants were asked to evaluate the taste intensity of the solutions by using the gLMS scale. The value of individual response to the intensity of increasing concentrations was obtained from the geometric mean of the response to each concentration. Thus the values below the cut-off were classified as low-response and the values considered above were considered as high-response. Liking was determined by the same method used to evaluate intensity of the sensations however the scale used was a liking scale that uses the "dislike extremely" on the left and "like extremely" on the right (Methven et al., 2016) (Annex 1.e).

2.3.2 Aroma intensity, taste and liking

The aroma intensity was determined by measuring the distance between the nose and the glass as you approach it from your nose. As the taster senses the aroma of the wine he stopped approaching the glass and registered the distance from the nose to the glass in centimeters with the help of a 20 cm ruler. The further away from your nose you smell the greater the aromatic intensity of the wine. Place the glass on the table and start to approach it from your nose. The tasters had to rate the aroma intensity of 4 increasing solutions of white wine, one witness solution with no aroma solution added, and the other three with 0,5 ml/L, 1 ml/L and 2 ml/L respectively, before tasting.

2.3.3 Taste and sensation intensity

To evaluate the intensity of the tastes (sweet, salty, acid) the tasters put the sample in the mouth, rinsed for 10 seconds, being sure that they covered all the mouth surfaces and waited for the sensation to peak (1—15s.) After, the tasters draw a mark on the VAS scale according to the intensity (Bartoshuk, 2000) (Annex 1.g).

2.3.4 Liking

At last the tasters evaluated the preference of the 4 solutions. Liking was determined by the same method used to evaluate intensity of the sensations however the scale used was a liking scale that uses the "dislike extremely" on the left and "like extremely" on the right (Methven et al., 2016).

2.4 Wine

The wine used in during the study was a Macabeo base wine from Instituto Superior de Agronomia produced in the year 2016 (Table 2.1). The wine was produced through the "bica aberta" method, the fermentation is performed with grapes without skin and lightly crushed. The wine used in the study was dry, medium to low acidity and with delicate notes of wildflowers and bitter almonds. The wine was flavored with increasing concentrations of one aroma mixture solution. Aroma compounds and their concentrations were chosen based on previous research of Gewurztraminer wines (Guth, 1997; Ong & Acree, 1999). The aroma solution in ethanol (Table 2.2) was composed by ethyl butanoate, 2-methylpropan-1-ol, isoamyl acetate, 3-methyl-butan-1-ol, ethyl hexanoate, 2-phenyl ethanol, cis-rose-oxide, acetaldehyde, linalool, ethyl octanoate and beta damascenone (Arvisenet, et al. 2015). The wine samples were freshly prepared on the day of the testing.

Table 2.1. Physicochemical parameters of the base white wine.

Parameter	Value
pH	3.52
Ethanol	11.3
Free SO_2 (mg/l)	39
Total SO_2 (mg/l)	105
Residual sugar (RS) (g/l)	0.7
Volatile acidity (g acetic acid/l)	0.23
Total acidity (g tartaric acid/l)	5.30

Table 2.2. Aroma solution compounds and their properties (Arvisenet,et al., 2015).

Name	Compound	Formula	Molar Mass	Odor description	Amount in aroma mixture (mg L^{1})
Isobutanol	2-methylpropan-1-ol	$C_4H_{10}O$	74.12	Sweet, sweaty-chemical, whiskey-like	16
Phenethyl alcohol	2-phenyl ethanol	$C_{10}H_{10}O$	122.16	Floral, rose	24.2
Isoamyl alcohol	3-methyl-butan-1-ol	$C_5H_{12}O$	88.15	Alcoholic, winey-brandy	95.2
Ethanal	Acetaldehyde	C_2HO_4	44.05	Pungent, breathtaking	0.94
Damascenone	□-damascenone	$C_{13}H_{18}O$	190.28	Fruity-floral with apple-plum-raisin, tea, rose, tobacco	0.008
Rose-oxide	Cis-rose-oxide	$C_{10}H_{18}O$	154.25	Metallic, grassy-green, geranium	0.042
Ethyl butanoate	Ethyl butanoate	$C_{16}H_{18}O_2$	116.16	Ether, fruity odor, buttery, ripe fruit	0.42

Ethyl hexanoate	Ethyl hexanoate	$C_8H_{16}O_2$	144.21	Fruity, winey odor; apple, banana, pineapple	1.02
Ethyl octanoate	Ethyl octanoate	$C_{10}H_{20}O_2$	172.27	Fruity, winey, sweet odor, cognac-apricot	1.02
Isoamyl acetate	Isoamyl acetate	$C_7H_{14}O_2$	130.18	Sweet, fruity, banana, pear	2.54
Linalool	Linalool	$C_{10}H_{18}O$	154.25	Floral-woody odor with faint citrus note, sweet floral	0.36

Four wine solutions were prepared with increasing order of concentration of the aroma solution, one control solution with no aroma solution added, and the other three with 0.5 ml/L, 1 ml/L and 2 ml/L of the aroma mixture (Table 2.3).

Table 2.3. Concentration of aromatic molecules added to wine.

Name	Concentration in aroma mixture (ml/L)	Wine 1	Wine 2	Wine 3	Wine 4
		0 ml/L	0.5 ml/L	1 ml/L	2 ml/L
Isobutanol	0.016	0	0.008	0.016	0.032
Phenethyl alcohol	0.0242	0	0.0121	0.0242	0.0484
Isoamyl alcohol	0.0952	0	0.0476	0.0952	0.1904
Ethanal	0.00094	0	0.00047	0.00094	0.00188
Damascenone	0.000008	0	0.000004	0.000008	0.000016
Rose-oxide	0.000042	0	0.000021	0.000042	0.000084
Ethyl butyrate	0.00042	0	0.00021	0.00042	0.00084
Ethyl caproate	0.00102	0	0.00051	0.00102	0.00204
Ethyl caprylate	0.00102	0	0.00051	0.00102	0.00204
Isopentyl acetate	0.00254	0	0.00127	0.00254	0.00508
Linalool	0.00036	0	0.00018	0.00036	0.00072

2.5 Data Analysis

Results obtained from panelists were subjected to variance analyses (α=0.05) with software R (www.r-project.org) to assess the influence of each segmentation type on wine liking. In order to evaluate possible interaction effects, we performed the factorial analyzes combining more than one segmentation type. For the segmentation types that showed influence on wine liking, mean comparisons were performed with Tukey's test α=0.05.

3. Results and Discussion

3.1 Taster Characterization

The tasting panel was composed by 21 females and 13 males, with 12 smokers, 3 occasional smokers and 19 assumed themselves as non-smokers. The results of the Vinotype online questionnaire showed that 9 were Hypersentive, 21 Sensitive and 4 Tolerant. The individual responses are listed in Annex 2.a. The remaining physiological features are described below.

3.1.1 PROP status

The subjects were classified into 3 categories, Non-Tasters, Medium-Tasters and Super-tasters, based in the bitterness rating assigned to the 0.32 mM PROP solution using the LMS scale (non-taster: ≤ 15.5; taster: ≥ 15.5 and < 51; super tasters ≥ 51) according to Tepper et al. (2001). The mean responses of each category to PROP bitterness and NaCl taste intensity are presented in Figure 3.1. The relation between PROP and NaCl followed the expected trend mentioned by Tepper et al. (2001), confirming the PROP status. In this study, there were 12 Non-Tasters and 20 Tasters and 2 Super-Tasters. Considering the low number of Super-Tasters, this group was merged with the Tasters group.

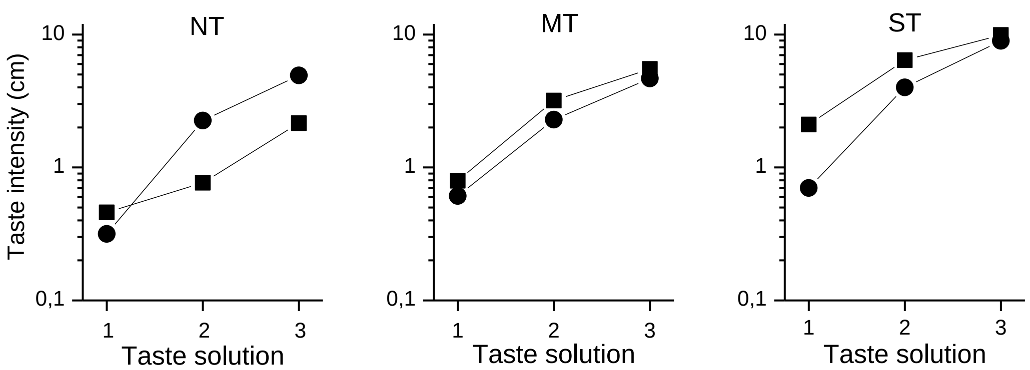

Figure 3.1. Taste intensities of PROP(▪) (1, 0.032 mM; 2, 0.32 mM; 3, 3.2 mM) and NaCl (●) solutions (1, 0.01 M; 2, 0.1 M; 3, 1 M) according to each PROP status (NT, Non-tasters; MT, Medium-tasters; ST, Super-tasters).

3.1.2 Saliva Flow

The average saliva flow of all tasters was 2.4 g/min. This value was used as cut-off to divide the panel according to their saliva production. High producers were those producing more than 2.4 g/min and low producers were those with the saliva flow lower than that amount (Figure 3.2).

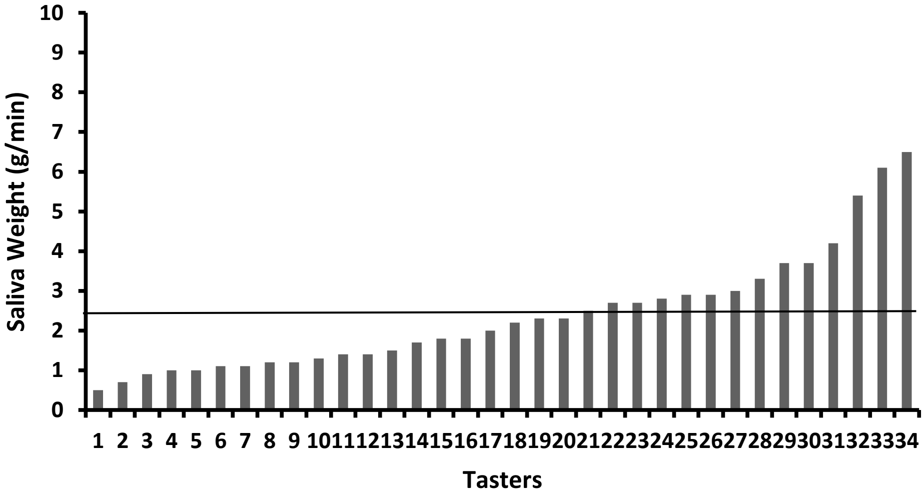

Figure 3.2. Saliva flow (g/min) of each taster. The horizontal line indicates the cut-off value between high and low producers (2.4 g/min).

3.1.3 Overall tasting panel characterization

The number of tasters in each category is shown in Table 3.1. The 34 individuals were separated in several classes within each category, comprising more than 7 tasters in all classes except for the Tolerants in the Vinotype. This number is considered by the ISO standard 5495 as the minimum of responses to obtain reliable comparisons with trained individuals (ISO, 2005).

Table 3.1. Characterisation of the tasting panel.

Categories		Gender		Smoker		Vinotype			PROP		Saliva flow	
		F	M	Y	N	H	S	T	M	N	LF	HF
Gender	F	**21**	-	10	11	7	12	2	12	9	5	16
	M	-	**13**	2	11	2	9	2	10	3	9	4
Smoker	Y	10	2	**12**	-	5	6	1	7	5	8	4
	N	11	11	-	**22**	4	15	3	15	7	10	7
Vinotype	H	7	2	5	4	**9**	-	-	4	5	6	3
	S	12	9	6	15	-	**21**	-	17	4	13	8
	T	2	2	1	3	-	-	**4**	1	3	1	3
PROP	MT	12	10	7	15	4	17	1	**22**	-	12	10
	NT	9	3	5	7	5	4	3	-	**12**	8	4
Saliva Flow	LF	5	9	8	12	6	13	1	12	8	**14**	-
	HF	16	4	4	10	3	8	3	10	4	-	**20**

F – Female; M – Male; Y – Yes; N – No; H – Hypersensitive; S – Sensitive; T – Tolerant; M – Medium-Taster; NT – Non-Taster; LF – Low flow; HF – High flow.

3.2 Intensity of prototypical tastes and sweet liking status

The intensities of taste or tactile sensations were evaluated using a gLMS scale for increasing concentrations of tartaric acid, tannic acid and sucrose in water solutions. The responses were log transformed and the resulting plots showed a linear relationship as illustrated in Figure 3.3.

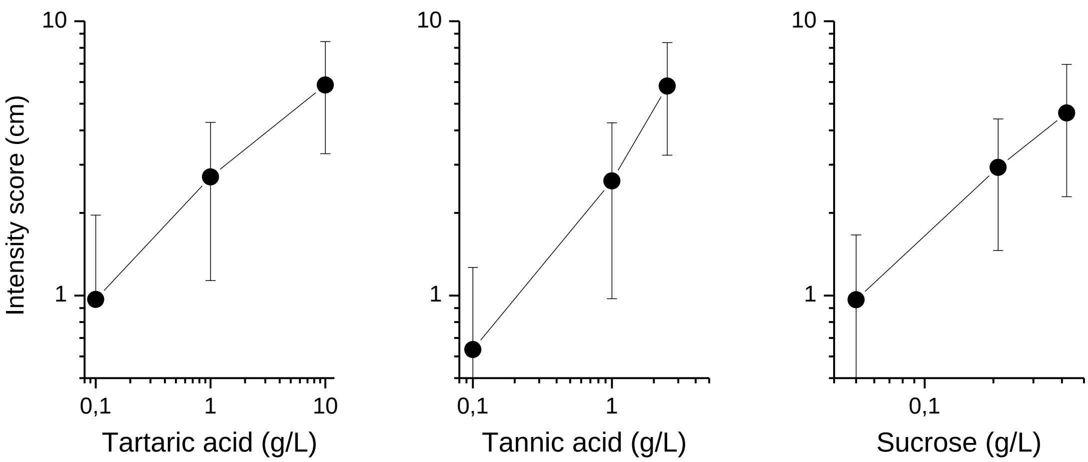

Figure 3.3. Intensity scores of tartaric acid, tannic acid and sucrose in water solutions.

The relatively high standard deviation of the mean values indicates a large variability in taster perceptions. In order to understand the distribution of these responses, the geometric mean of each taster response across the 3 concentrations of each molecule may provide a measure of the individual sensitivity. The distribution of these geometric means is shown in Figure 3.4 for each tastant (tartaric acid, tannic acid, sucrose), together with the scores given to PROP bitterness and NaCl saltiness mentioned in the previous section.

One of the most common measures of taste function is PROP responsiveness. It would be interesting to evaluate the relation between the different taste responses to see if it could be related with other taste sensitivities. The results are shown in Figure 3.5. There was a positive trend between PROP and all other tastants although the correlations (r values) were not high for NaCl (0.47), tartaric acid (0.45), sucrose (0.28) and for tannic acid (0.34), meaning that these tastes and astringent sensations were only moderately correlated. Computing all responses, individuals may be divided in high and low responsive to the stimuli using a cut-off value equivalent to the mean of the overall intensity measure for each tastant. The number of tasters in each class is shown in Table 3.2. Regarding sodium chloride, 14 tasters showed high sensitivity and 20, low sensitivity. With tartaric acid, 16 tasters had high sensitivity and 18, low sensitivity. As for tannic acid, 14 tasters had high sensitivity and the other 20 low sensitivity.

Interestingly, the individual mean value of all intensities provided a good correlation with PROP responsiveness (0.68) as shown in Figure 3.6. All other tastants provided slightly better correlations with the overall responsiveness (tartaric acid, 0.81; NaCl, 0.75; tannic acid, 0.76; sucrose, 0.82) (results not shown).

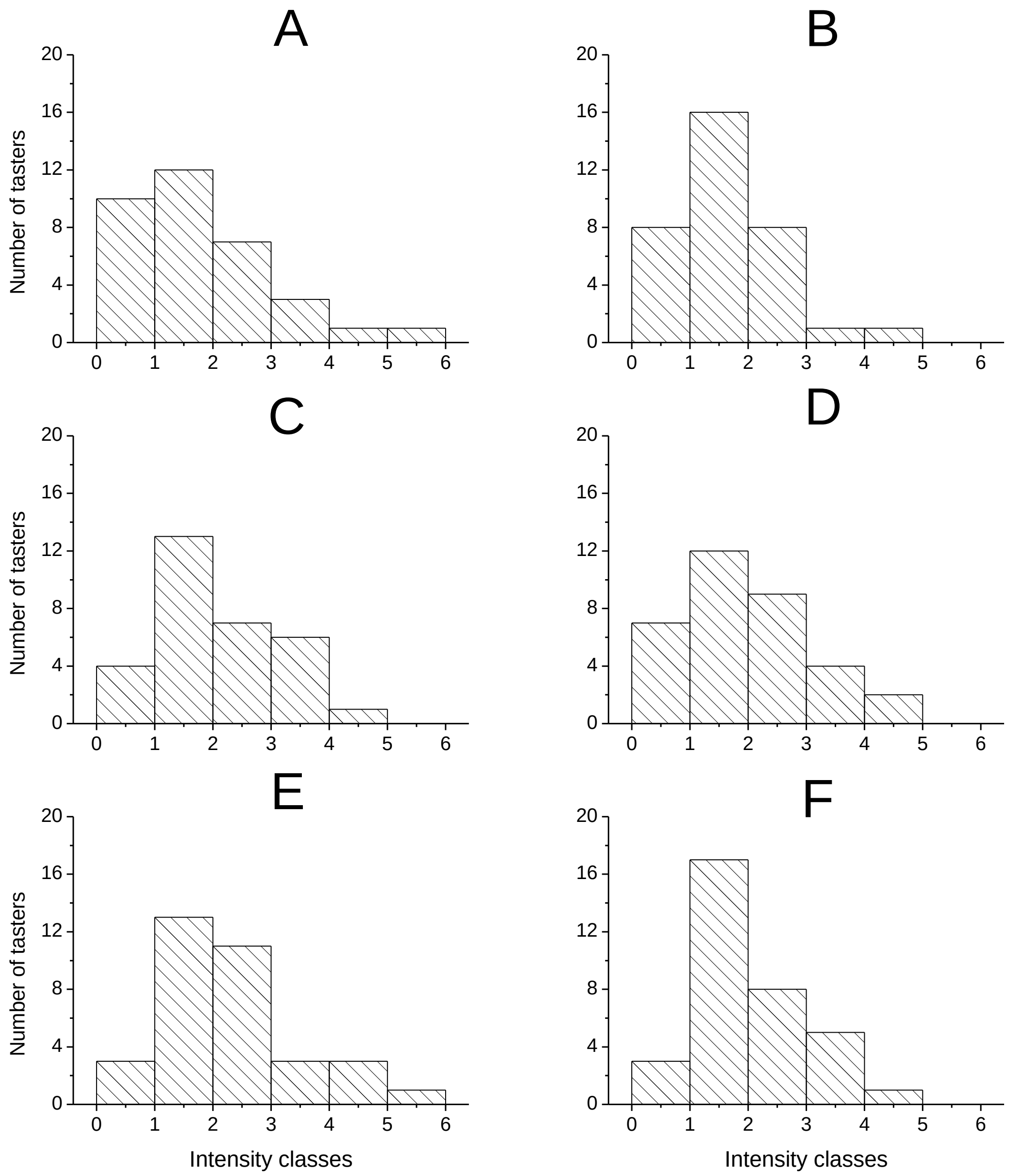

Figure 3.4. Distribution of intensity sensitivities to PROP (A), NaCl (B), tartaric acid (C), tannic acid (D), sucrose (E) and overall mean sensitivity (F).

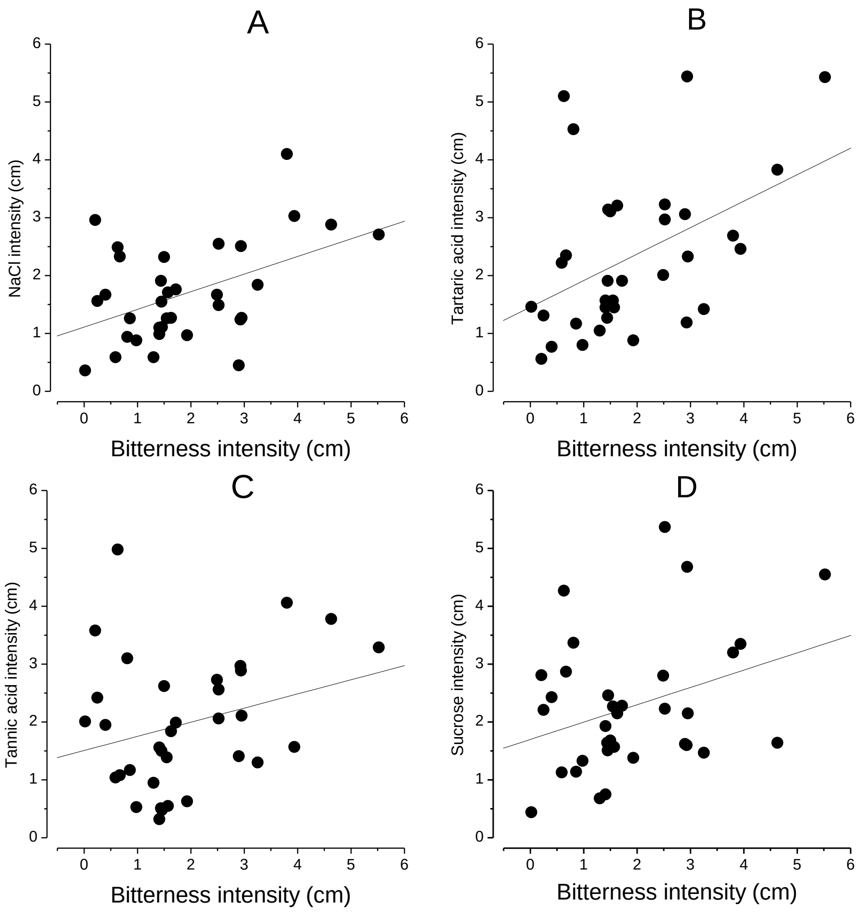

Figure 3.5. Relations between PROP responsiveness and mean intensity scores of NaCl (A), tartaric acid (B), tannic acid (C) and sucrose (D).

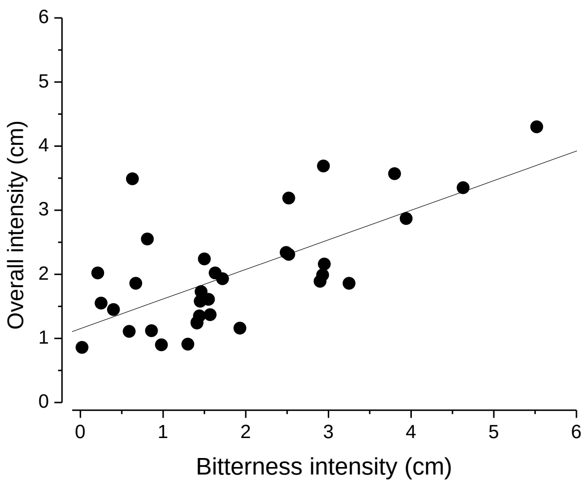

Figure 3.6. Relations between PROP responsiveness and mean intensity scores for all tastes and sensations.

By individuating the overall responses, we observed that only one taster revealed high responses to all tastes including liking to the sweet solution. Three tasters revealed high responses to all tastes but dislike the sweet solution. Regarding low responsive tasters, five revealed low responses to all tastes disliking the sweet solution. Only one taster revealed low responses to all tastes liking the sweet solution.

Table 3.2. Taster characterization according to tastes sensitivity and tactile sensations.

Categories		NaCl		TartA		TanA		Sucrose		Overall		Sweet liking	
		H	L	H	L	H	L	H	L	H	L	D	L
NaCl	H	**14**		9	5	9	7	9	5	9	5	11	3
	L		**20**	6	14	5	13	5	15	5	15	12	8
Tartaric Acid	H	9	6	**15**		10	5	9	6	12	3	13	2
	L	5	14		**19**	6	13	5	14	2	17	10	9
Tannic Acid	H	9	5	10	6	**16**		9	7	12	4	14	2
	L	7	13	5	13		**18**	5	13	2	16	9	9
Sucrose	H	9	5	9	5	9	5	**14**		9	5	11	3
	L	5	15	6	14	7	13		**20**	5	15	12	8
Overall	H	9	5	12	2	12	2	9	5	**14**		14	11
	L	5	15	3	17	4	16	5	15		**20**	9	0
Sweet Liking	D	11	12	13	10	14	9	11	12	14	9	**23**	
	L	3	8	2	9	2	9	3	8	11	0		**11**

H – High; L – Low; D – Disliker, L – Liker.

The establishment of sweet liking status followed the studies of Methven et al. (2016) and Asao et al. (2015). Our goal was to obtain a measure of sweet liking to relate with taste responsivity. The method used a single concentration of sugar (205 g/L of sucrose) and observed its preference using a VAS scale. The distinction between sweet likers and sweet dislikers was made using the cut-off value of 75 mm (mid-point of the VAS scale) as suggested by Asao et al. (2015). The lowest value recorded was of 0.4 cm, while the highest value was 13.2 cm (Annex 2.i). Most of the tasters (23) were considered Sweet dislikers while 11 were Sweet likers.

Concerning the relation between taste sensitivity and sugar liking did not reveal a particular relation with an r = - 0.27 (Figure 3.7). In particular, only 2 out of 7 tasters with high responses to all tastes were sweet likers. The other 5 tasters were sweet dislikers. Regarding the low responsive tasters, 4 of them were sweet likers and the remaining 7 were sweet dislikers.

The relation between sweet liking and responsiveness to sweetness was moderate and negative (-0.44) (Figure 3.8), indicating that those sensitive to sweet tend to be sweet dislikers.

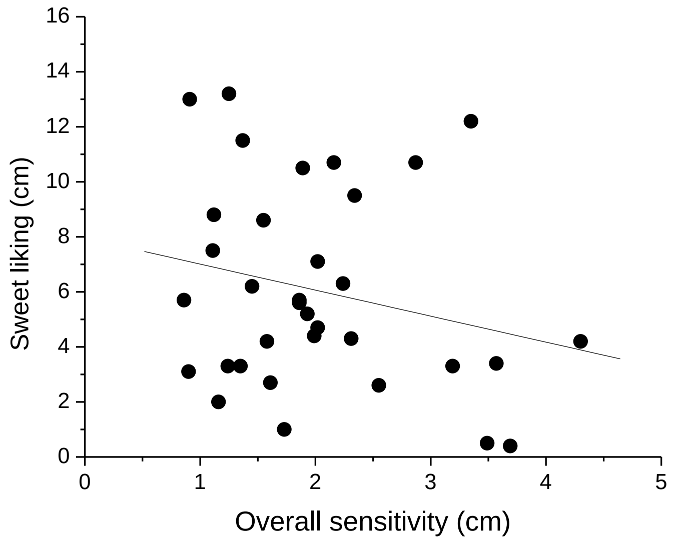

Figure 3.7. Relation between overall sensitivity to tastes and sensations and sweet liking.

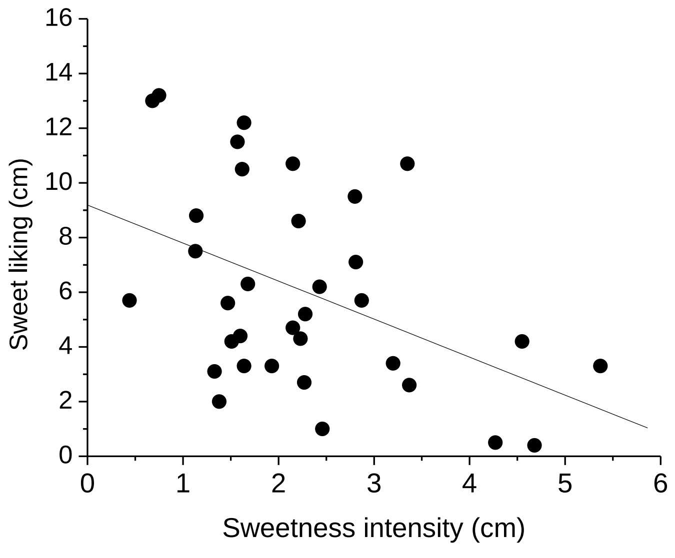

Figure 3.8. Relation between sweetness intensity and sweet liking.

3.3 Relation among tastes and sensations in white wine

3.3.1 Intensity evaluation of tartaric acid, tannic acid and sucrose

The intensity of tastants added to wine induced increasing responsivity. The results are shown in Figure 3.9, demonstrating a high variability in the responses. A measure of individual sensitivity was obtained by calculating the geometric mean of the scores across all tastant concentrations. The distribution of these mean sensitivities is depicted in Figure 3.10, showing that responses to sucrose and tartaric acid followed approximately a Gaussian distribution while to tannic acid, the distribution was skewed to the left. This fact led us to separate the tasters into high and low sensitivities, using the arithmetic average of each individual tastant intensity (geometric mean) as cut-off value.

The correlations among the 3 tastants are shown in Figure 3.11, demonstrating moderate to low correlations (r=0.50 between sucrose and tartaric acid; r=0.36 between sucrose and tannic acid and r=0.49 between tartaric and tannic acids). The representation of Figure 3.12 shows the variation of mean intensities across the concentrations of the 3 tastants, showing individuals with high and low responsiveness. A measure of the overall sensitivity to wine tastants was obtained by calculating the average of each individual sensitivity (geometric mean). The distribution of these overall sensitivities is shown in Figure 3.10 (D).

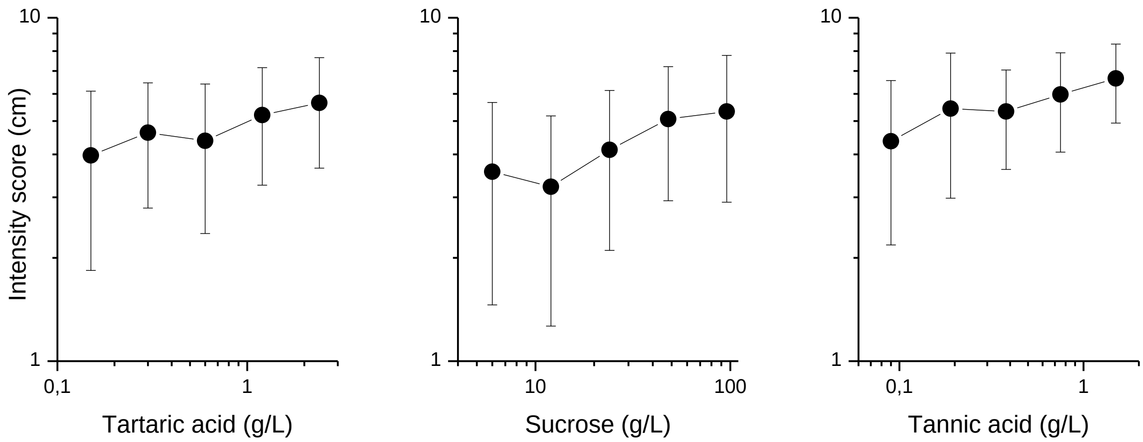

Figure 3.9. Intensity scores induced by increasing concentrations of tartaric acid, sucrose and tannic acid in white wine.

Table 3.3. Taste intensity of white wine spiked with increasing concentrations of tartaric acid, tannic acid and sucrose.

Stimulus	**Concentration (g/L)**	**P-value**	**Intensity (mean ± sd)**
Tartaric acid	0.15	0.00567	$3.97^{a} \pm 2.13$
	0.30		$4.62^{ab} \pm 1.83$
	0.60		$4.38^{ab} \pm 2.03$
	1.20		$5.20^{ab} \pm 1.95$
	2.40		$5.65^{b} \pm 2.00$
Tannic acid	0.09	0.000165	$4.37^{a} \pm 2.19$
	0.19		$5.43^{ab} \pm 2.45$
	0.38		$5.33^{ab} \pm 1.71$
	0.75		$5.98^{b} \pm 1.92$
	1.50		$6.65^{b} \pm 1.72$
Sucrose	6	9.23E-05	$3.56^{a} \pm 2.10$
	12		$3.22^{a} \pm 1.96$
	24		$4.12^{ab} \pm 2.02$
	48		$5.06^{b} \pm 2.13$
	96		$5.33^{b} \pm 2.43$

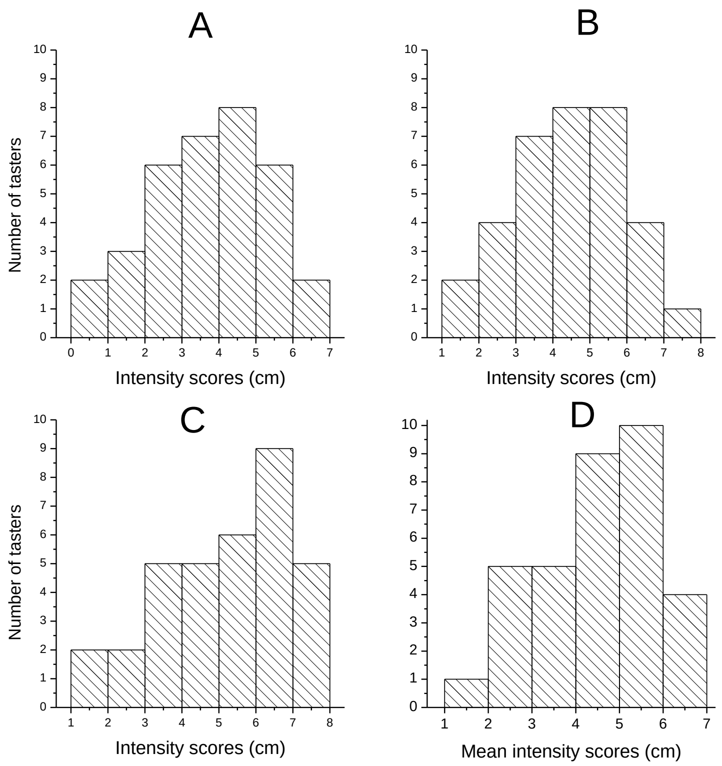

Figure 3.10. Distribution of mean sensitivities to sucrose (A), tartaric acid (B), tannic acid (C) and overall mean (D) in white wine.

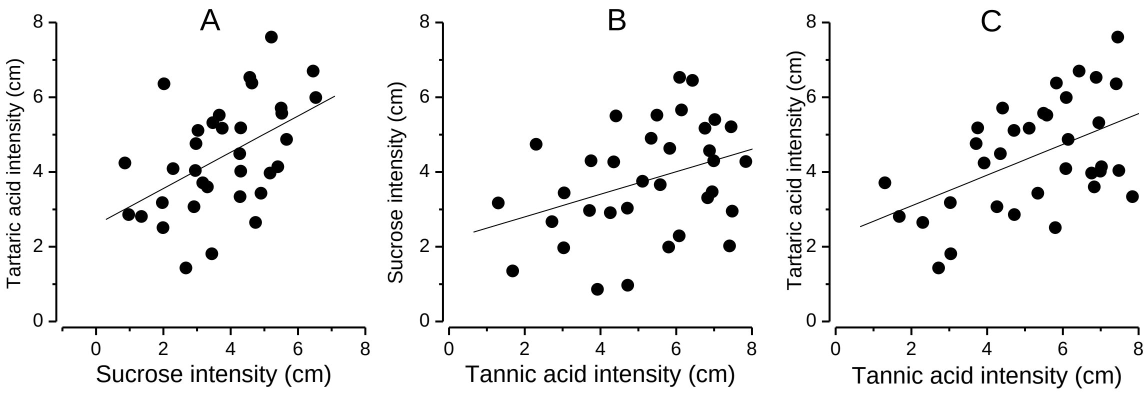

Figure 3.11. Relation between intensities of sucrose and tartaric acid (A), tannic acid and sucrose (B) and tannic acid and tartaric acid (C). Straight lines were obtained by linear regression.

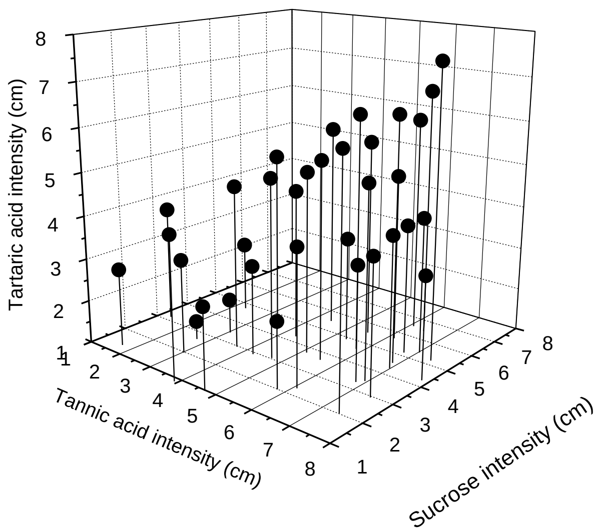

Figure 3.12. Intensity scores given by the tasters to sucrose, tartaric acid and tannic acid.

3.3.2 Prototypical taste responsiveness and taste sensitivity in wine

In order to find if the sensitivity to PROP could predict the sensitivity to tastants in wine we analysed the correlation among all tastants The results are shown in Figure 3.13 and demonstrate that taste sensitivities are not related to PROP responsiveness. All r values were less 0.2 (results not shown). These values were much lower than the correlation obtained in water solution described in previous section, which may be explained by the effect wine matrix that blurs the perception of each tastant or sensation. In addition, responsiveness to the prototypical tastes in water (tartaric acid, tannic acid, sucrose) were also not correlated (r=0.01) with the mean intensity scores given to the same tastants in wine (Figure 3.14). As a result, the tasters highly responsive to these tastants belonging to the top quintile (7 tasters) in water or in wine were different except in one individual. Regarding the low quintile, 3 tasters coincided in both low sensitivity groups. Interestingly, one individual placed in the water top quintile was included in the wine low quintile.

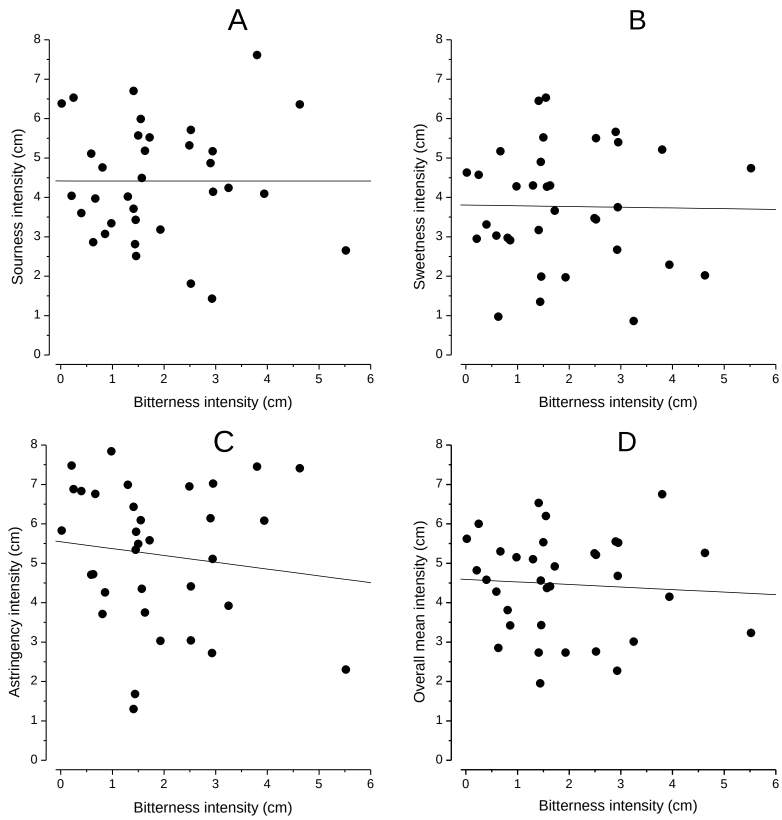

Figure 3.13. Relations between PROP responsiveness and mean intensity ratings in wine of tartaric acid (A), sucrose (B), tannic acid (C) and of mean intensity of all tastants (D).

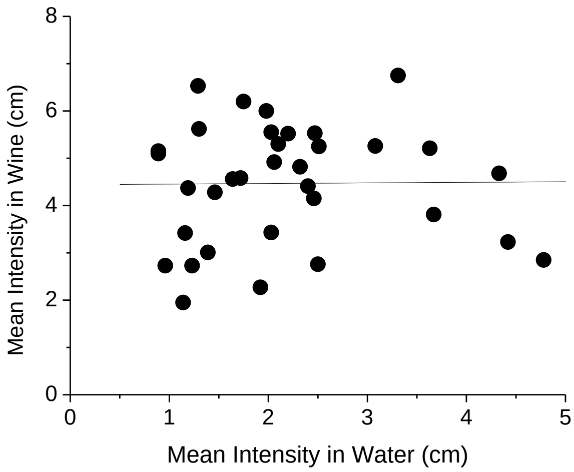

Figure 3.14. Relation between the mean intensity perception of tartaric acid, tannic acid and sucrose in water solution and in wine.

3.4 Relation between wine liking, intensity perception and sweet liking

3.4.1 Liking of white wine spiked with tartaric acid, sucrose and tannic acid

The intensity evaluation mentioned before was accompanied by the corresponding liking assessment for the 3 molecules added to white wine. These scores were rather variable across individuals as demonstrated by the high standard deviations of the mean (Table 3.4). By computing the geometric mean of the liking scores for each taster and for each molecule, we obtained the distribution shown in Figure 3.15.

Table 3.4. Liking scores of white wine spiked with increasing concentrations of tartaric acid, tannic acid and sucrose.

Stimulus	Concentration (g/L)	P-values	Liking (mean ± sd)
Tartaric acid	0.15	0.565	6.77[a]±2.71
	0.30		6.75[a]±3.30
	0.60		6.58[a]±3.11
	1.20		6.27[a]±2.78
	2.40		5.73[a]±2.78
Tannic acid	0.09	0.0302	5.72[ab]±2.62
	0.19		5.19[ab]±3.40
	0.38		5.81[a]±2.74
	0.75		4.65[ab]±3.03
	1.50		3.78[b]±2.81
Sucrose	6	0.0271	6.38[a]±2.72
	12		6.97[a]±2.51
	24		6.48[a]±2.68
	48		5.28[a]±2.94
	96		5.15[a]±2.98

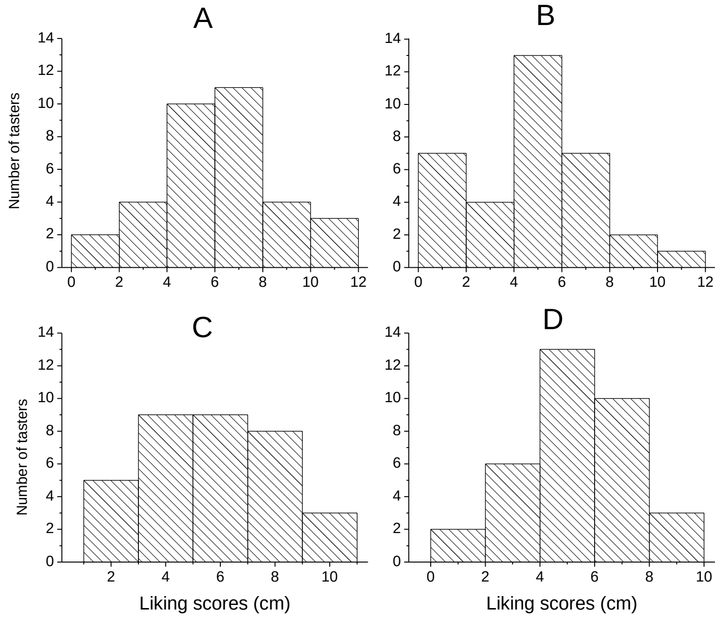

Figure 3.15. Distribution of mean liking scores of tartaric acid (A), tannic acid (B), sucrose (D), and overall liking (D) in white wine.

By splitting the liking scores using the average liking as cut-off value it was possible to obtain two classes of liking for each tastant, one of high likers and the other of low likers. Figure 3.16 shows the preference response of each tastant for both classes.

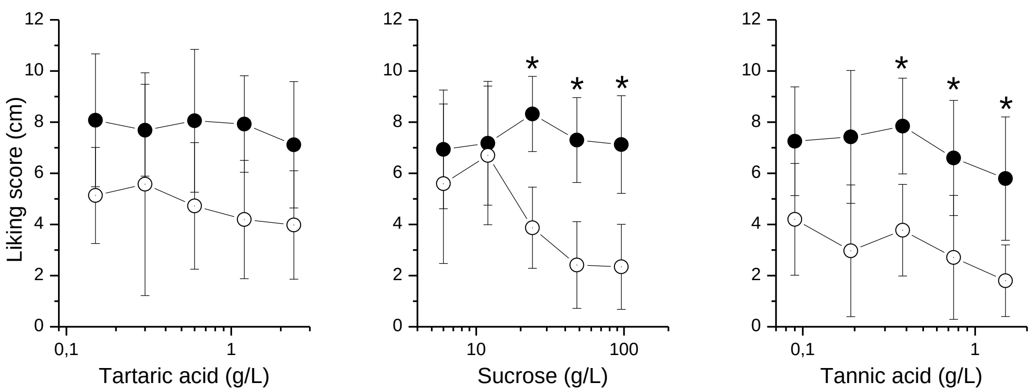

Figure 3.16. Liking scores induced by increasing concentrations of tartaric acid, sucrose and tannic acid in white wine according to High (●) and Low (○) liking classes. Asterisk denotes significant differences ($p<0.05$) between classes.

Table 3.5. Liking scores of tartaric acid, sucrose and tannic acid in white wine spiked with increasing concentrations of tartaric acid, tannic acid and sucrose, according to High and Low liking classes.

Stimulus	**Concentration (g/L)**	**High Liking**		**Low Liking**	
		P-value	**Score (mean ± sd)**	**P-value**	**Score (mean ± sd)**
Tartaric acid	0.15	0.702	$8.07^{a} \pm 2.59$	0.504	$5.13^{a} \pm 1.88$
	0.30		$7.68^{a} \pm 1.79$		$5.57^{a} \pm 4.35$
	0.60		$8.05^{a} \pm 2.79$		$4.73^{a} \pm 2.47$
	1.20		$7.93^{a} \pm 1.89$		$4.19^{a} \pm 2.31$
	2.40		$7.12^{a} \pm 2.47$		$3.98^{a} \pm 2.11$
Tannic acid	0.09	0.0844	$7.25^{a} \pm 2.12$	0.014	$4.20^{a} \pm 2.18$
	0.19		$7.42^{a} \pm 2.60$		$2.97^{ab} \pm 2.58$
	0.38		$7.85^{a} \pm 1.87$		$3.78^{ab} \pm 1.79$
	0.75		$6.60^{a} \pm 2.25$		$2.71^{ab} \pm 2.42$
	1.50		$5.79^{a} \pm 2.41$		$1.80^{b} \pm 1.40$
Sucrose	6	0.206	$6.94^{a} \pm 2.32$	1.48E-06	$5.59^{ab} \pm 3.12$
	12		$7.17^{a} \pm 2.42$		$6.70^{a} \pm 2.71$
	24		$8.32^{a} \pm 1.47$		$3.87^{bc} \pm 1.59$
	48		$7.30^{a} \pm 1.66$		$2.41^{c} \pm 1.69$
	96		$7.13^{a} \pm 1.91$		$2.34^{c} \pm 1.66$

3.4.2 Relation between liking and intensity perception

The relation between taste perception and liking was obtained through Pierson correlation coefficients. The [r] values were 0.17 for tartaric acid, 0.19 for sucrose and 0.38 for tannic acid, showing that wine liking was not correlated with sensitivity to sour or sweet taste (Figure 3.17). The perception of astringency was negatively correlated with wine appreciation but with a poor coefficient. When all tastant responsiveness (average of geometric means of each taste/sensation) were plotted against the respective mean liking, the Pierson correlation coefficient was also low (r=0.14) demonstrating that white wine acceptance was independent from taste sensitivity (Fig. 3.18).

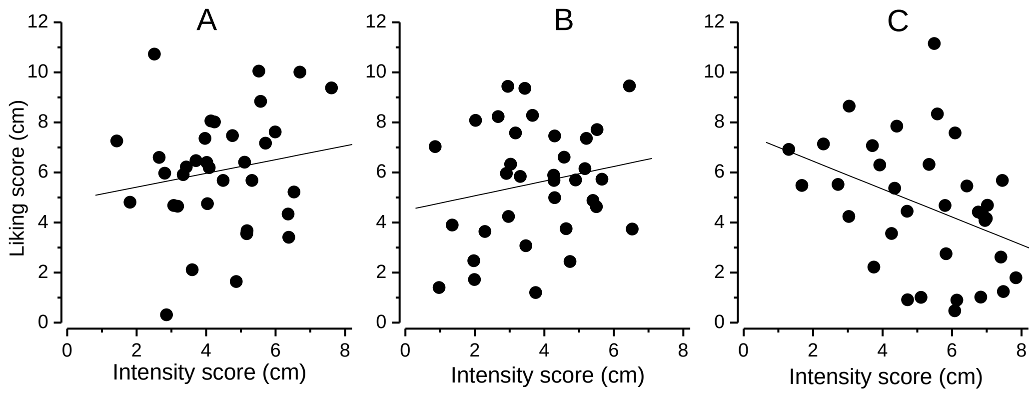

Figure 3.17. Relation between intensity and liking scores for tartaric acid (A), sucrose (B) and tannic acid (C). Straight lines were obtained by linear regression.

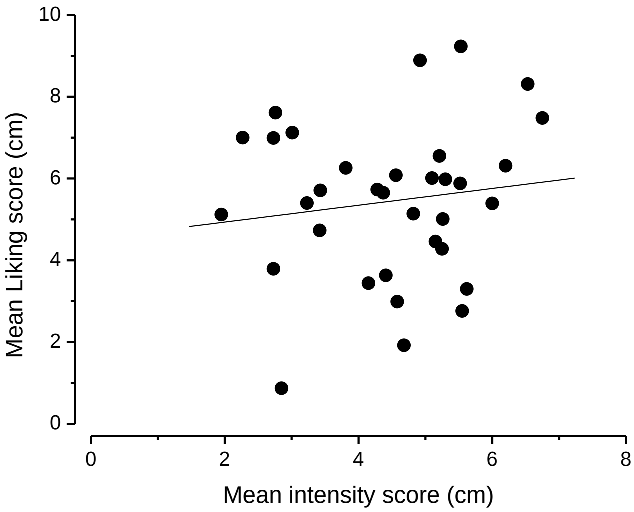

Figure 3.18. Relation between mean liking and mean intensity scores of all tastants.

3.4.3 Relation among liking scores

In order to find possible relations between liking measures, the sweet liking score given to a sucrose solution of 205 g/l was plotted against the mean liking score (Fig. 3.19). The coefficient obtained (r=0.11) showed that these two parameters were not related.

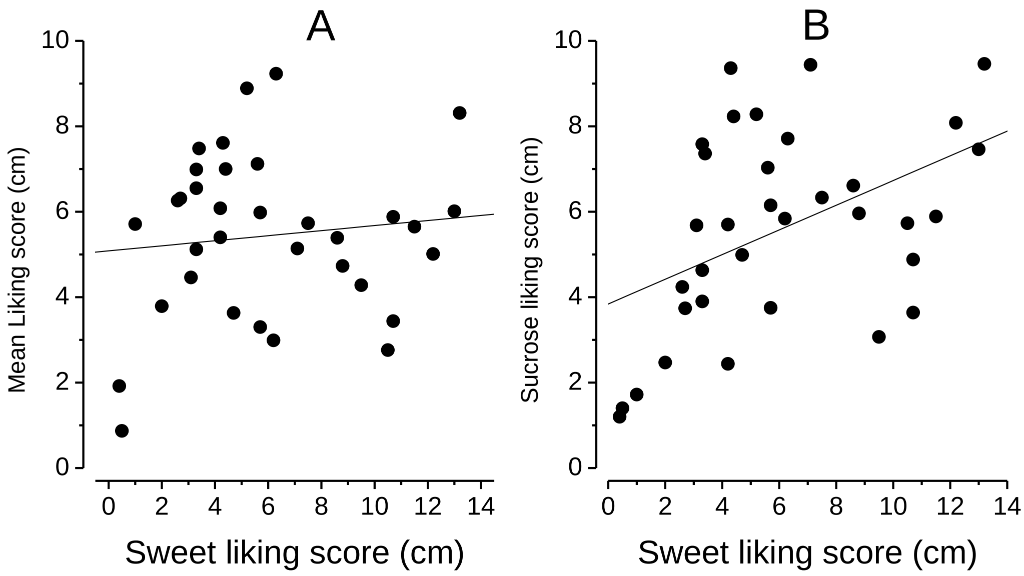

Figure 3.19. Relation between sweet liking scores and mean liking scores (A) and sucrose liking (B) for all tastants.

Further insight into the taste liking in wine was obtained by exploring the relation with the sweet liking status (Figure 3.19). Interestingly, a r=0.45 was achieved demonstrating the into some extent, the sweet liking status may predict the preference for sweeter wines. However, the low correlation led us to evaluate other factors that influence wine sweetness like the intensity of fruit/flavors, as described below.

3.5 Influence of white wine aroma on sensory and liking responses

3.5.1 Smell and taste intensity evaluation

After performing the previous mouthfeel sensitivity tests, the tasting panel assessed the smell intensity of the same white wine but now spiked with increasing levels of a flavor mixture mimicking the fruity and floral notes of a white wine. The orthonasal smell intensity was measured as the distance (in cm) from the glass top where the smell begins to be felt. The overall results are shown in Table 3.6, revealing and increase in smell intensity as a function of the flavor mixture concentration. The scores ranged from 0.5 cm to 20 cm resulting in high standard deviations for each concentration. The gradual increase in intensity resulted in different ($p<0.05$) scores between the control and the highest flavor concentration (Table 3.6). In parallel, tasters were asked to score the taste intensities of sweetness, sourness and saltiness perceived in the wines spiked with increasing flavor concentrations. The significance ($p<0.05$) of the difference across the intensities of the different wines was evaluated by ANOVA. Considering as factor wine with increasing aroma concentrations and as variable the aroma intensity, the comparison of scores demonstrated that tasters produced different responses in aroma and sweetness intensities between the base wine and the last flavor concentration while differences in acidity and saltiness were not observed (Table 3.6).

Table 3.6. Smell, taste intensities and liking of white wine spiked with increasing concentrations of a flavor mixture according to smell sensitivity classes (1, control wine; 2, control plus 0.5 mL/L; 3, control plus 1 mL/L; 4, control plus 2 mL/L).

Category	Wine	All tasters		High smell sensitivity tasters		Low smell sensitivity tasters	
		P-values	Mean ± sd	P-values	Mean ± sd	P-values	Mean ± sd
Aroma Intensity	1	0.0455*	$8.19^{b}\pm4.38$	0.109	$12.07^{a}\pm3.47$	0.00347*	$5.48^{b}\pm2.50$
	2		$8.79^{ab}\pm3.29$		$11.75^{a}\pm2.44$		$6.71^{ab}\pm1.93$
	3		$9.51^{ab}\pm3.62$		$12.50^{a}\pm2.87$		$7.43^{ab}\pm2.44$
	4		$10.74^{a}\pm4.02$		$14.32^{a}\pm2.93$		$8.23^{a}\pm2.46$
Sweetness Intensity	1	0.0096*	$2.79^{b}\pm2.23$	0.033*	$1.99^{b}\pm1.58$	0.123	$3.34^{a}\pm2.48$
	2		$3.02^{ab}\pm1.88$		$3.20^{ab}\pm2.24$		$2.90^{a}\pm1.63$
	3		$3.88^{ab}\pm1.81$		$3.60^{ab}\pm1.57$		$4.07^{a}\pm1.98$
	4		$4.29^{a}\pm2.31$		$4.12^{a}\pm2.18$		$4.40^{a}\pm2.45$
Acidity Intensity	1	0.207	$5.51^{a}\pm1.78$	0.256	$5.16^{a}\pm2.13$	0.452	$5.75^{a}\pm1.49$
	2		$5.20^{a}\pm2.22$		$3.97^{a}\pm2.50$		$6.05^{a}\pm1.54$
	3		$4.59^{a}\pm2.24$		$3.49^{a}\pm2.33$		$5.35^{a}\pm1.86$
	4		$5.57^{a}\pm2.21$		$4.78^{a}\pm2.61$		$6.13^{a}\pm1.74$
Saltiness Intensity	1	0.830	$4.45^{a}\pm2.18$	0.706	$4.19^{a}\pm2.07$	0.94	$4.63^{a}\pm2.29$
	2		$4.12^{a}\pm2.14$		$3.54^{a}\pm2.06$		$4.53^{a}\pm2.15$
	3		$4.06^{a}\pm2.14$		$3.21^{a}\pm2.25$		$4.64^{a}\pm1.89$
	4		$4.42^{a}\pm2.29$		$3.70^{a}\pm2.49$		$4.93^{a}\pm2.04$
Liking score	1	0.534	$7.07^{a}\pm2.88$	0.710	$7.28^{a}\pm3.31$	0.714	$6.92^{a}\pm2.62$
	2		$7.26^{a}\pm2.79$		$7.05^{a}\pm2.94$		$7.41^{a}\pm2.74$
	3		$6.91^{a}\pm2.19$		$6.54^{a}\pm1.69$		$7.17^{a}\pm2.48$
	4		$6.36^{a}\pm2.71$		$6.21^{a}\pm2.51$		$6.46^{a}\pm2.91$

[a] Mean values in the same column for each category followed by different letters are significantly different ($p<0.05$).

The individual values of intensity scores for each flavor concentration were geometrically averaged and this value was taken as the individual smell sensitivity score. The distribution of the geometric mean scores is shown in Figure 3.20. The average of the geometric means was 9.04 cm which was used as the cut-off value between classes of high and low sensitive tasters, with 14 and 20 individuals, respectively. In Figure 3.20 are shown the overall responses and those of each taster sensitivity class.

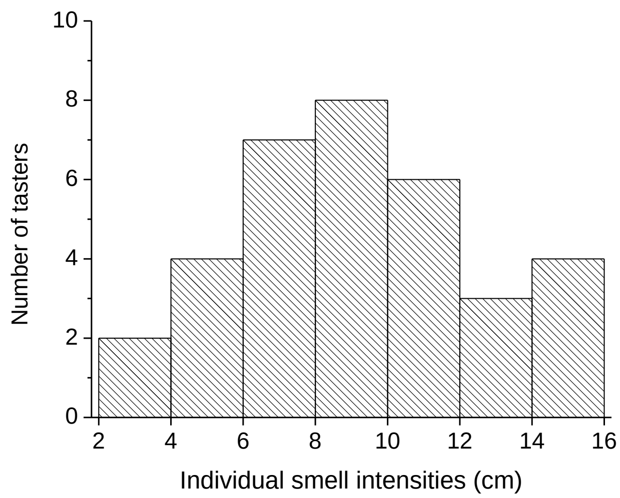

Figure 3.20. Distribution of the geometric mean of smell intensity scores given by the tasters to all wines spiked with increasing flavor concentration.

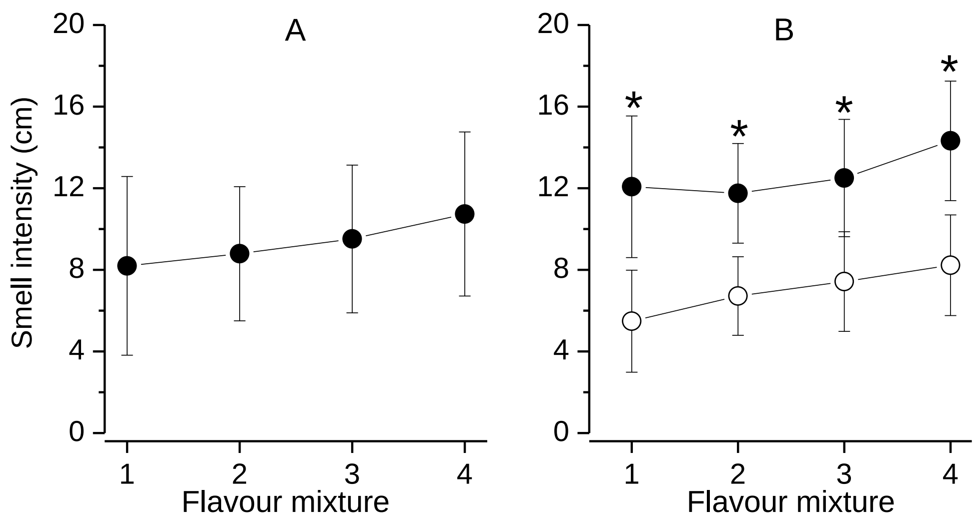

Figure 3.21. Smell intensity of white wine spiked with increasing flavor mixture concentrations (1, control wine; 2, control plus 0.5 mL/L; 3, control plus 1 mL/L; 4, control plus 2 mL/L) (A, all tasters; B, Low sensitive tasters and High sensitive tasters). Asterisks denotes significant differences ($p<0.05$) between High (●) and Low (○) sensitive tasters.

In addition, the separation of tasters according to smell sensitivity enabled to observe their differences in taste sensitivities. Regarding sweetness, low smell sensitives produced higher scores with increasing flavor concentration while high smell sensitives showed a tendency to increasing sweetness but without differences between the control wine and the last flavor concentration (Table 3.6). Responsiveness to acidity and saltiness were constant across the 4 different flavored wines, irrespective of the smell sensitivity (Table 3.6).

Further insight on the influence of smell sensitivity on the taste responsiveness was achieved by comparing the behaviour of each sensitivity class. Interestingly, high and low smell sensitives produced different responses to acidity and saltiness. The high sensitives produced lower responses to acidity and salt, while low sensitives reported higher intensity for acid and salt perceptions (Table 3.7). By comparing scores for each flavor concentration, the difference in acidity perception was justified by the scores given to the intermediate flavor concentrations while differences in saltiness were not evidenced when comparing the response to each concentration (Table 3.8). The behaviour of each sensitivity class is illustrated in Figure 3.22.

Table 3.7. Smell and taste sensitivities given by high and low smell sensitive tasters to white wines spiked with increasing aroma concentrations ($p<0.05$).

Categories	**P-value**	**High sensitive**	**Low sensitive**
		Mean^{a} ± sd	**Mean ± sd**
Aroma Intensity	2.00E-16*	12.66^{a} ± 3.04	6.96^{b} ± 2.51
Sweetness Intensity	0.232	3.23^{a} ± 2.03	3.68^{a} ± 2.20
Acidity Intensity	5.02E-05*	4.35^{a} ± 2.43	5.82^{b} ± 1.66
Saltiness Intensity	0.00642*	3.66^{a} ± 2.19	4.69^{b} ± 2.07
Liking	0.636	6.77^{a} ± 2.64	6.99^{a} ± 2.66

[a] Mean values in the same row followed by different letters are significantly different ($p<0.05$).

The P-value difference in Saltiness Intensity, between Table 3.6 and Table 3.7, is due to the number of responses, while for the concentration there are four response variables (C0, C0.5, C1, C2 with 34 responses each) in the profile sensitivity there are only two responses (High sensitive – 14 / Low sensitive – 20). The data in Table 3.7 was analyzed together (34), while on Table 3.6 was analyzed separately.

Table 3.8. Taste intensities of white wine spiked with increasing flavor concentrations (1, control wine; 2, control plus 0.5 mL/L; 3, control plus 1 mL/L; 4, control plus 2 mL/L), according to smell sensitivity classes.

Categories	Wine	P-values	High sensitive	Low sensitive
			Mean[a] ± sd	**Mean ± sd**
Sweetness Intensity	1	0.082	1.99[a]±1.59	3.34[a]±2.48
	2	0.654	3.20[a]±2.25	2.90[a]±1.63
	3	0.476	3.60[a]±1.57	4.06[a]±1.98
	4	0.737	4.13[a]±2.18	4.40[a]±2.45
Acidity Intensity	1	0.348	5.16[a]±2.13	5.75[a]±1.49
	2	0.005	3.97[b]±2.50	6.05[a]±1.54
	3	0.014	3.49[a]±2.33	5.35[a]±1.86
	4	0.079	4.77[a]±2.61	6.13[a]±1.74
Saltiness Intensity	1	0.569	4.19[a]±2.07	4.63[a]±2.29
	2	0.190	3.54[a]±2.06	4.53[a]±2.15
	3	0.053	3.21[a]±2.25	4.64[a]±1.89
	4	0.125	3.70[a]±2.49	4.93[a]±2.04
Liking	1	0.722	7.28[a]±3.31	6.92[a]±2.62
	2	0.717	7.05[a]±2.93	7.41[a]±2.74
	3	0.415	6.54[a]±1.69	7.17[a]±2.48
	4	0.794	6.20[a]±2.51	6.46[a]±2.91

[a] Mean values in the same row followed by different letters are significantly different ($p<0.05$).

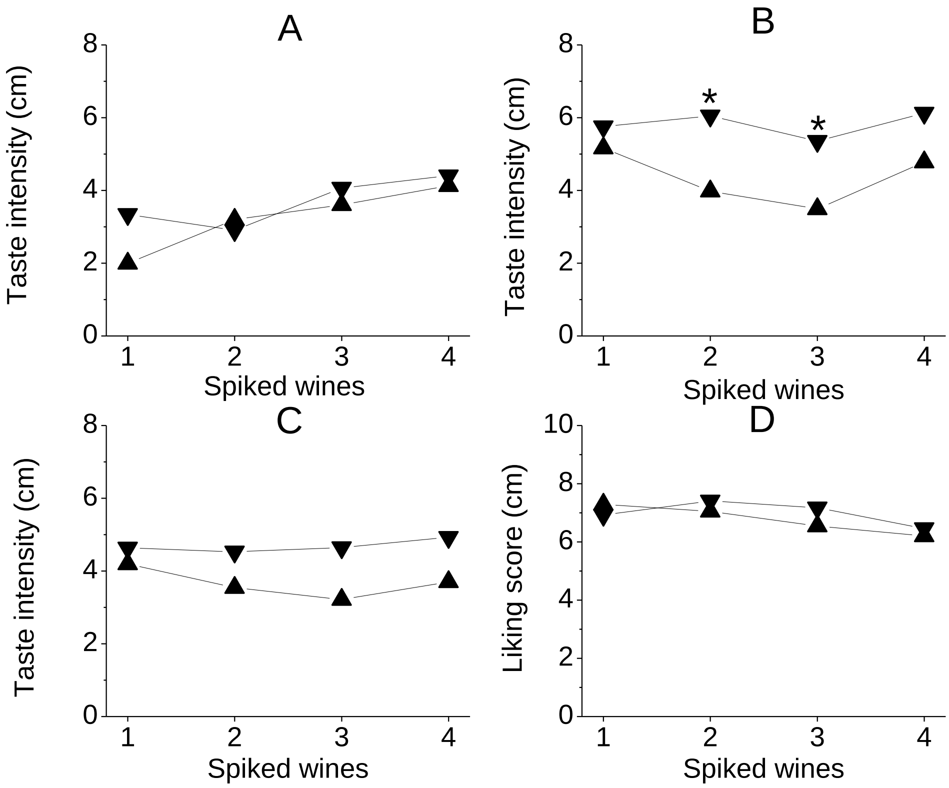

Figure 3.22. Taste intensities (A, sweetness; B, sourness; C, saltiness) and liking (D) of white wine spiked with increasing flavor concentrations (1, control wine; 2, control plus 0.5 mL/L; 3, control plus 1 mL/L; 4, control plus 2 mL/L), according to smell sensitivity (▲, High smell sensitivity; ▼, Low smell sensitivity). Asterisks denote significant differences ($p<0.05$) between high and low smell sensitive tasters.

3.5.2 Liking responses according to smell sensitivity

The results described before demonstrated that tasters perceived different smell intensities in the wines spiked with increasing aroma concentrations. Considering all tasters, the results presented in Table 3.6 showed that this perceived increasing smell intensity resulted in increased sweetness intensity ($p<0.05$) while acid and salt intensities did not vary. These results demonstrate that the liking score may only be ascribed to variations in smell and sweetness intensities. However, the liking responses were similar across all flavor concentrations ($p<0.05$), therefore the variation on increased flavor our sweetness perceptions did not affect wine appreciation, regardless the taster separation according to the sensitivity to smell.

3.5.3 Influence of taster categories on flavor sensitivity and liking

The previous results were obtained for all tasters and it would be interesting if the different categories could yield different responses to the white wine spiked with increasing flavor concentrations. An ANOVA considering the different taster categories (Gender, Smoker, Vinotype, PROP Status, Saliva flow, NaCl sensitivity, Tartaric acid sensitivity, Tannic acid sensitivity and Sweet liking) as factors and taste intensity or liking scores as predictors was performed. The results showing significant differences ($p<0.05$) are described below.

The Vinotype was found to influence the responses in all smell and taste perceptions (Table 3.9). Interestingly, smell intensity perception decreased from hypersentives to tolerants. The sensitives perceived higher flavor sweetness than hypersensitives and tolerants, while hypersensitives and sensitives were more responsive to acidity than tolerants. The tolerants produced the lowest responses to saltiness, although results were only produced by 4 tasters. Sweet likers were also more responsive to white wine acidity than sweet dislikers.
The influence of the tested physiological features was not frequent. PROP status influenced aroma intensity perception, with medium PROP tasters yielding higher smell intensities than non-tasters. High salt responsiveness in water solution yielded higher acid intensities in white wine. Low saliva producers yielded higher responses to saltiness.

The liking scores given to the white wines with increasing aroma concentration was found to be dependent on more taster categories ($p<0.05$) than the smell or taste perception scores (Table 3.10). The higher liking scores were given by males, non-smokers, medium PROP tasters and low saliva producers. Interestingly, Vinotype classes yielded different responses, sensitives were those preferring the white wines, followed by hypersensitives and tolerants.

Considering significant liking and sensory responses together, PROP medium tasters preferred the aromatic white wines when compared to non-tasters. Vinotype sensitives also preferred these wines although their responsiveness to smell was intermediate.

Table 3.9. Effect of taster categories on smell and taste intensities.

Perception	Categories	Class	P-values	Mean ± sd	Number of Tasters
Aroma Intensity	Vinotype	H	0.0141	$10.75^{a}\pm4.09$	9
		S		$9.02^{ab}\pm3.80$	21
		T		$7.59^{b}\pm3.27$	4
	PROP	M	0.0307	$9.84^{a}\pm4.06$	22
		N		$8.33^{b}\pm3.50$	12
Sweetness Intensity	Vinotype	H	0.0114	$2.84^{b}\pm2.03$	9
		S		$3.92^{a}\pm2.11$	21
		T		$2.72^{b}\pm2.05$	4
Acidity Intensity	Vinotype	H	0.0019	$5.52^{a}\pm2.14$	9
		S		$5.42^{a}\pm2.04$	21
		T		$3.48^{b}\pm1.86$	4
	NaCl	H	0.043	$5.66^{a}\pm1.90$	14
		L		$4.91^{b}\pm2.24$	20
	Sweet Liking	L	0.0283	$5.80^{a}\pm1.98$	11
		D		$4.94^{b}\pm2.16$	23
Saltiness Intensity	Vinotype	H	0.0015	$5.13^{a}\pm1.87$	9
		S		$4.16^{ab}\pm2.24$	21
		T		$2.86^{b}\pm1.63$	4
	Saliva flow	HF	0.0203	$3.75^{b}\pm2.01$	20
		LF		$4.62^{a}\pm2.22$	14

HS – Hypersensitive; S – Sensitive; Tolerant; M – Medium taster; N – Non-taster; H – High; L – Low; LK – Like; D – Dislike; HF – High flow; LF – Low flow.

Table 3.10. Effect of taster categories on liking scores.

Categories		P-values	Mean ± sd	Tasters
Gender	F	0.0163	$6.47^{b}\pm2.73$	21
	M		$7.59^{a}\pm2.37$	13
Smoker	N	0.00267	$7.39^{a}\pm2.55$	22
	Y		$5.98^{b}\pm2.61$	12
Vinotype	H	2.21E-05	$6.36^{b}\pm2.52$	9
	S		$7.58^{a}\pm2.39$	21
	T		$4.51^{c}\pm2.72$	4
PROP	M	0.045	$7.23^{a}\pm2.40$	22
	N		$6.28^{b}\pm2.98$	12
Saliva Flow	HF	0.00173	$6.06^{b}\pm2.74$	20
	LF		$7.48^{a}\pm2.43$	14

F – Female; M – Male; N – No; Y – Yes; HS – Hypersensitive; S – Sensitive; Tolerant; M – Medium taster; N – Non-taster; HF – High flow; LF – Low flow.

3.5.4 Influence of taste sensitivity in wine on flavor sensitivity and liking

The previous taste sensitivity results were obtained using the taster categorisation obtained with water solutions. In the course of this work, tasters were also separated according to their orosensory responsiveness to molecules added to wine. Therefore, it would be interesting to observe any possible influence of these sensitivities on the perception of wine spiked with increasing flavor concentrations. The results presented in Table 3.11 showed that tasters highly sensitive to all tastes or to sucrose scored aroma intensity with higher values. Those highly sensitive to tannic acid perceived higher sweetness. No other relations were obtained with individual tastants. Interestingly, using the overall sensitivity classification significant results were obtained regarding aroma intensity, while the taste intensities had p value close, but higher than, to 0.05.

Table 3.11. Effect of sensitivity categories elicited by wine on smell and taste intensities of wine spiked with increasing flavor concentrations.

Perception	Categories	Class	P-values	Mean ± sd	Tasters
Aroma Intensity	Tartaric Acid	H	0.179	$9.81^{a}\pm3.76$	15
		L		$8.90^{a}\pm4.03$	19
	Tannic Acid	H	0.314	$9.67^{a}\pm3.82$	16
		L		$8.99^{a}\pm4.00$	18
	Sucrose	H	0.049*	$10.09^{a}\pm3.35$	14
		L		$8.75^{b}\pm4.21$	20
	Overall	H	0.035*	$10.15^{a}\pm3.98$	14
		L		$8.71^{b}\pm3.79$	20
Sweetness Intensity	Tartaric Acid	H	0.173	$3.78^{a}\pm2.26$	15
		L		$3.27^{a}\pm2.02$	19
	Tannic Acid	H	0.00309*	$4.04^{a}\pm1.99$	16
		L		$2.98^{b}\pm2.14$	18
	Sucrose	H	0.943	$3.51^{a}\pm2.22$	14
		L		$3.48^{a}\pm2.09$	20
	Overall	H	0.0642	$3.90^{a}\pm2.16$	14
		L		$3.21^{a}\pm2.09$	20
Acidity Intensity	Tartaric Acid	H	0.638	$5.31^{a}\pm2.25$	15
		L		$5.14^{a}\pm2.04$	19
	Tannic Acid	H	0.0663	$5.58^{a}\pm1.99$	16
		L		$4.90^{a}\pm2.21$	18
	Sucrose	H	0.304	$5.44^{a}\pm2.02$	14
		L		$5.06^{a}\pm2.21$	20
	Overall	H	0.0859	$5.59^{a}\pm2.08$	14
		L		$4.95^{a}\pm2.14$	20
Saltiness Intensity	Tartaric Acid	H	0.946	$4.27^{a}\pm2.37$	15
		L		$4.25^{a}\pm2.01$	19
	Tannic Acid	H	0.369	$4.44^{a}\pm2.46$	16
		L		$4.10^{a}\pm1.88$	18
	Sucrose	H	0.885	$4.29^{a}\pm2.19$	14
		L		$4.24^{a}\pm2.17$	20
	Overall	H	0.506	$4.41^{a}\pm2.34$	14
		L		$4.16^{a}\pm2.06$	20

H – High; L – Low.

The liking scores given to the wines spiked with flavor mixtures could not be predicted from the sensitivities to wine tastants. The p-values shown in Table 3.12 showed that wine appreciation was not significantly correlated with responsiveness to overall or individual tastes.

Table 3.12. Effect of taster sensitivity categories on liking of white wine spiked with increasing flavor concentrations.

Perception	Categories	Class	P-values	Mean ± sd	Number of Tasters
Liking	Tartaric Acid	High	0.575	$6.75^{a} \pm 2.74$	15
		Low		$7.01^{a} \pm 2.59$	19
	Tannic Acid	High	0.508	$7.06^{a} \pm 2.82$	16
		Low		$6.76^{a} \pm 2.49$	18
	Sucrose	High	0.308	$6.62^{a} \pm 3.08$	14
		Low		$7.09^{a} \pm 2.29$	20
	Overall	High	0.831	$6.96^{a} \pm 2.88$	14
		Low		$6.86^{a} \pm 2.49$	20

H – High; L – Low.

4. Discussion

4.1 Overall taste sensitivities in water and in white wine

Webb et al. (2015) comparing several measures of taste function concluded that there are multiple perceptual phases of taste with no single measure able to capture the totality of the sense of taste. Our results concur with these observations, showing low or moderate correlations between the sensitivity to suprathreshold concentrations of NaCl, tartaric acid, sucrose, tannic acid and PROP bitterness. By gathering all tastant responses (geometric mean of all taste intensity scores) we could distinguish individuals with high or low sensitivities. Increased or decreased taste response to multiple stimuli has been named as hypergeusia or hypogeusia by Hayes and Keast (2011). These authors claimed that this definition is more precise than that of PROP status because it is limited to responses to bitterness.

In addition, our results also demonstrated the influence of the tasting media on taste sensitivity. When tastants were diluted in wine there was no correlation between PROP responses and sensitivities to tartaric acid, sucrose and tannic acid in water. The correlations among tastants (tartaric acid, sucrose, tannic acid) diluted in wine were low to moderate but higher than the correlations between PROP and these tastants in water. Therefore, the assessment of overall taste sensitivities in wine related studies should involve the use of wine media to determine individual sensitivities.

4.2 Relationships between taste sensitivities and liking

The final goal of our work is to assess if wine liking can be predicted by any particular taste sensitivity in wine. The correlations between wine liking and individual taste sensitivities were absent for tartaric acid and sucrose. A moderate negative correlation was obtained for tannic acid indicating that astringency was not appreciated by the tasting panel. However, considering the notions of hypogeusia and hypergeusia there was no correlation between overall liking and overall taste sensitivity.

The sweet liking status induced by tasting 205 g/L sucrose in water was also evaluated. As expected, there was no correlation with overall wine liking. However, a moderate correlation ($r=0.45$) was obtained with the liking scores of wine spiked with sucrose. Therefore, in some extent the sweet liking status as suggested by Asao et al. (2015) may also be applied to predict the preference for sweetness in white wines.

4.3 The interaction between white wine smell and taste

The work of Sáenz-Navajas et al. (2010) stating that an apparent simple response to flavor intensity could not yield coherent results led to the development of a simple method to score the individual orthonasal sensitivity to smell. In this work, this smell intensity was determined by measuring the distance between the nose and the glass when the orthosonal smell starts to be sensed. This method enabled to separate the tasters as high or low smellers which were both sensitive to the increase in the flavor concentration induced in white wine by spiking with a mixture of aromatic molecules.

The increase in wine flavor could also induce modifications in other taste responses and influence the liking not because of flavor but because of changes in other sensations. The wine spiked with increasing aromatic molecules only induced differences in the sweetness perception provided by the tasting panel responses. Sour or salt perceptions were not affected by this methodology and so taster liking responses could be attributed only to different smell and sweetness perceptions. These results were expected as there is a congruent response between the floral/fruity flavor ("sweet" flavor) and the perception of sweetness.

Another aspect, only evidenced by the separation between the two smell sensitivity classes, was the relation with sourness and saltiness. High smell sensitivity individuals reported lower scores for sourness and saltiness. This result suggests that the senses of smell (orthonasal) and taste are not independent and some evidence has been presented and discussed under the frame of oral referral (Spence, 2016).

4.4 Relations among taster characteristics and wine flavour-taste responses

Most of the taster categories could not be related with the scores given to smell or taste intensities. An exception, was the PROP status, when medium tasters yielded higher smell intensity scores than non-tasters, revealing a relation between smell and taste. High salt responsiveness was not related with saltiness perception but to acidity perception. Low saliva producers were more responsive to wine saltiness than high saliva producers.

Interestingly, only Vinotype provided significant correlations across all smel and taste sensitivities. Hypersensitives gave higher scores than tolerant to smell, acid and saltiness intensities. On the contrary, sweetness intensity was higher in sensitives then on hypersensitives or tolerants. Considering that Vinotype has not been tested in controlled experiments, these results illustrate some relation between wine preferences and taste sensitivities as described by Hanni (2012).

4.5 Factors affecting wine liking

The appreciation of white wines across all flavor concentrations was not related with smell sensitivity or sweetness perception. These results were in accordance with the initial tests revealing absence of correlation with taste sensitivities. Overall, these results show that sensory sensitivity only plays a moderate role, if any, on wine liking. Therefore, correlations were evaluated using taster characterization according to gender, smoking habits, wine expertise, sweet liking, vinotype, PROP status and saliva production. Considering all white wines spiked with flavor, the higher scores were given by males, non-smokers, PROP medium tasters and low saliva producers. Interestingly, a self-reported questionnaire regarding wine preferences (Vinotype) provided different responses according to the output. Higher scores were given by sensitives, followed by hypersensitive and tolerant tasters. Therefore, our study shows that wine liking is mostly dependent on taster features related with idiosyncratic preferences.

5. Limitations of the study

One of the limitations of this study was the relatively small tasting panel size and diversity. After taster categorization, several classes remained with few respondents limiting the significance of the results and justifying further experiments with other tasting panels. Tasters were selected mostly from enology students of similar age which is not a representative sample of overall wine consumers. It is understandable that these students may share somewhat common preferences reflecting their background studies that may not be generalized to the overall population.

The research related with the effect of flavor or taste on wine sensory features is most frequently based on synthetic wine in order to better standardize the matrix under evaluation. However, wine complexity is difficult to simulate in a water solution. Therefore, a real white wine would be more meaningful. However, although providing more realistic results than when using water solutions or synthetic wines, the conclusions may not be applied to other wines.

6. Conclusions and future prospects

The research carried out in this work was aimed at understanding which factors contribute to wine preference by the consumers. Therefore, focus was put on taster characterization on demographic, physiological or preference features. The responsiveness to tastes was not only evaluated with conventional methods (PROP status, saliva flow, taste and mouth-feel sensitivities) but also with an overall measure of sensitivity to tastes in wine. The results showed that tasters can be separated into high and low sensitives and that an overall sensitivity measure may be obtained from the sum of sensitivities to individual tastes. Moreover, high taste sensitivity was also related with high orthonasal smell sensitivity, justifying further studies to understand these flavor-taste relations.

However, these flavor-taste sensitivities were poor predictors of wine liking. With the tested white wine with increasing fruity flavor, wine preferences were mostly dependent on gender, smoking habits, PROP status and salivary flow. It was interesting to find that a questionnaire like the Vinotype could yield results closely related with white wine preference. We can argue that wine appreciation is much more dependent on individual culture, background and familiarity to certain styles than on physiological responses to tastes and flavors. Future research on the area should then include these aspects to better understand the individual drivers of consumer preference.

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Annexes

1. **Tasting Sheets**
    a. **Evaluation of sensations**

Date___/__/______

Name ____

Imagine having the following five sensations:

1) Sourness of a lemon;

2) Pain from biting your tongue;

3) Coolness of an ice-cold beverage;

4) Burning sensation from eating a whole hot pepper;

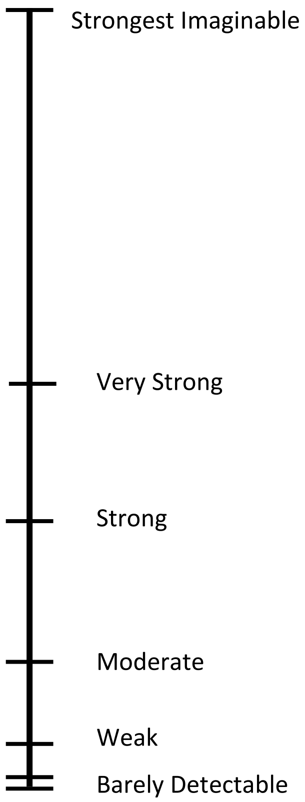
5) Brightness of the sun when you are looking directly at it.

Please rate the intensity of the five remembered sensations by drawing a horizontal line across each scale.

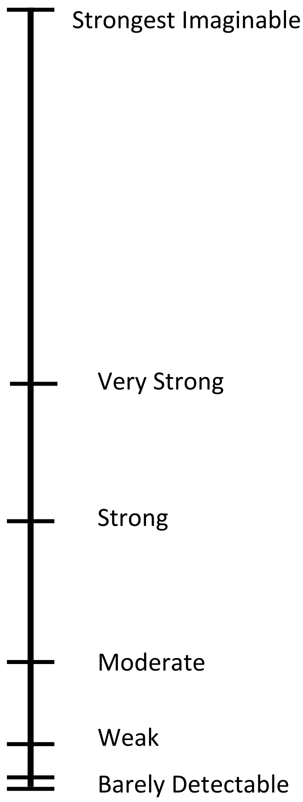
Write down the most intense sensation in any modality that you could ever imagine experiencing.

---

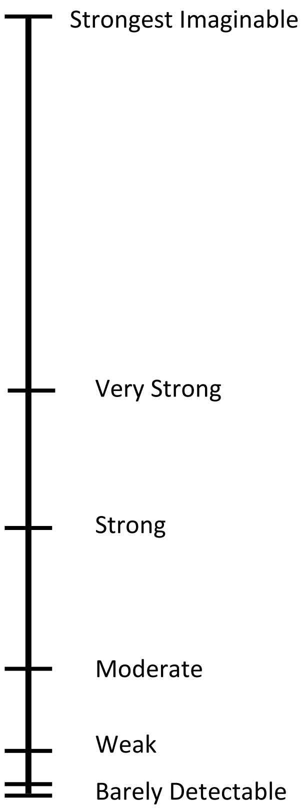
1) Sourness of a lemon



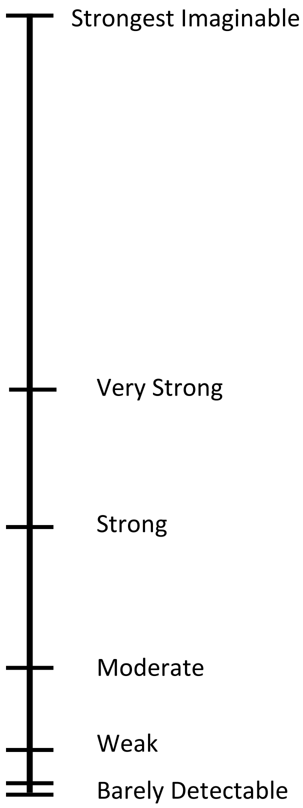
2) Pain from biting your tongue



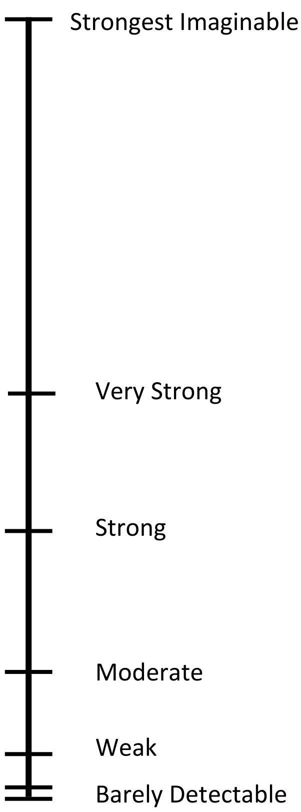
3) Coolness of an ice-cold beverage



4) Burning sensation from eating a whole hot pepper



5) Brightness of the sun when you are looking directly at it



b. Demographic and Saliva Flow

Date___/__/______

Name ____

Age__________ Gender (F/M) ____ Country ____________________

Study Background _________________________

Smoker (Y/N/Sometimes) ________ Vegetarian (Y/N) _________ Food Allergy (Y/N) _____

Vinotype _________________________

Wine Expertise

I don't drink wine	
Beginner	
Intermediate	
Very high	

Saliva Flow

Taste the sample given to you, hold it in the mouth for 10/15 seconds. Spit it out. Hold for another 10 seconds and spit in the plastic cup for a minute.

Initial Weight	
Total Weight	
Saliva Weight	

c. Vinotype

Website: www.myvinotype.com

I really love (click all that apply):

- Black coffee;
- Salt, lots of salt;
- Hot Spicy food. Hot, hot, HOT!;
- Exploring new wines from around the world;
- Cream and sugar in my coffee;
- A really nice scotch and/or cognac;
- Terroir – Wines with a sense of place;
- Sushi.

I really hate (click all that apply):

- Flavorings in my coffee like hazelnut, vanilla;
- Learning about wine – just let me drink it;
- Loud restaurants;
- The 100-point Rating System;
- The taste of some artificial sweeteners;
- Sweet wines;
- Cilantro;
- Altoids mints.

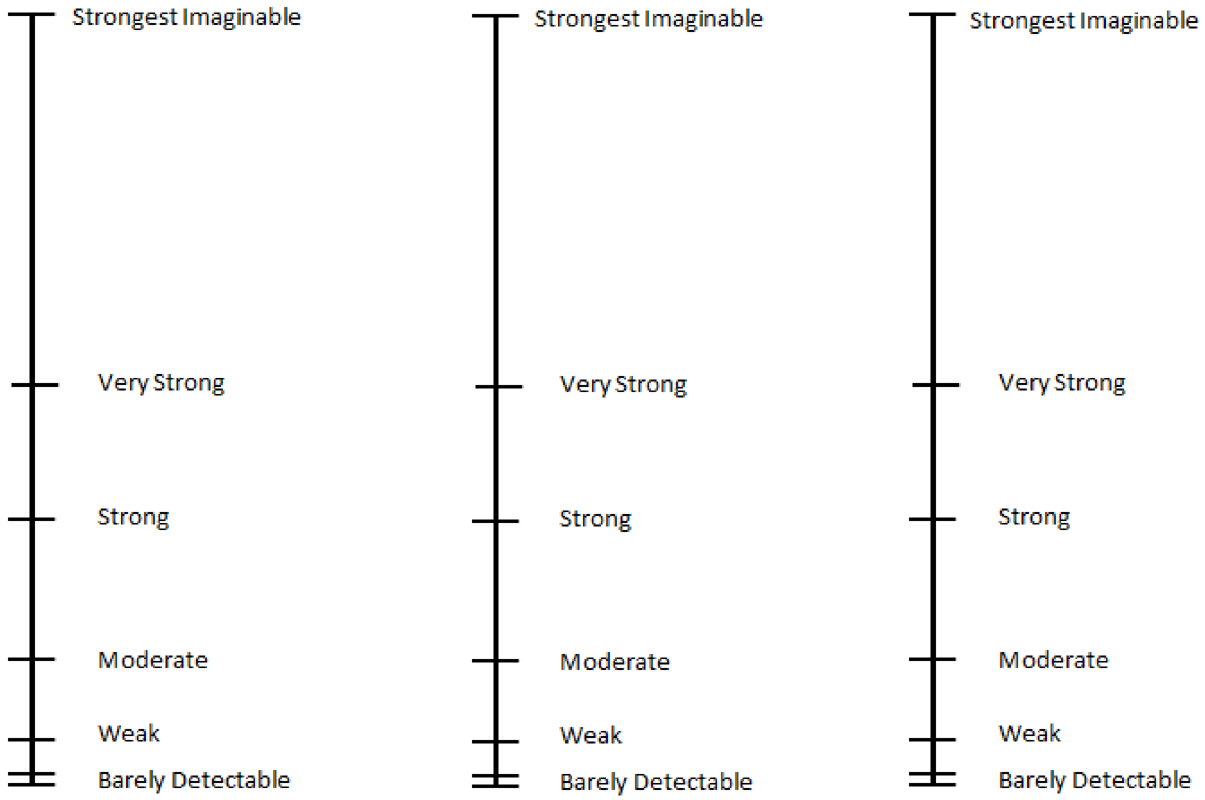
I really want (click all that apply):

- Soft towels;
- White, rose or blush wine with steak;
- To be a wine expert;
- Wine experts to focus on me, not wine;
- Red wine. Period.;
- Red wine and chocolate;
- Complex wines;
- Wines rated 90 to 100 points.

d. **PROP Status, Sodium Chloride, Tartaric Acid, Tannic Acid and Sucrose Intensity (Water)**

Name ____

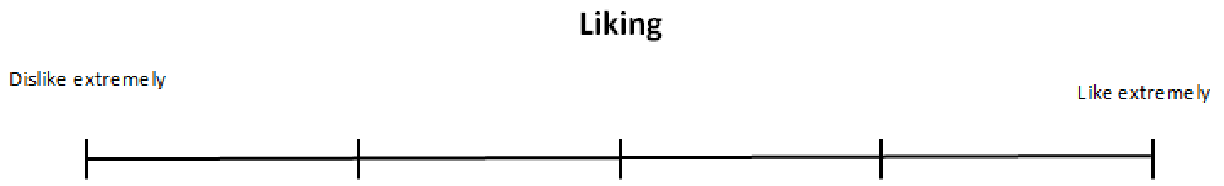
Rinse with water before beginning. Put the sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation intensity to peak (10-15 s). The maximum intensity is 10 seconds after spiting. After you taste the first sample rate the intensity of the sensation by drawing a mark on the LMS Scale. Rinse with spring water and wait 1 minute between samples. Repeat the same procedure with the other 2 samples.



e. Sweet Liking Status

Name

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.) The maximum intensity is 10 seconds after spiting. After, draw a mark on the liking scale according to your personal preference.

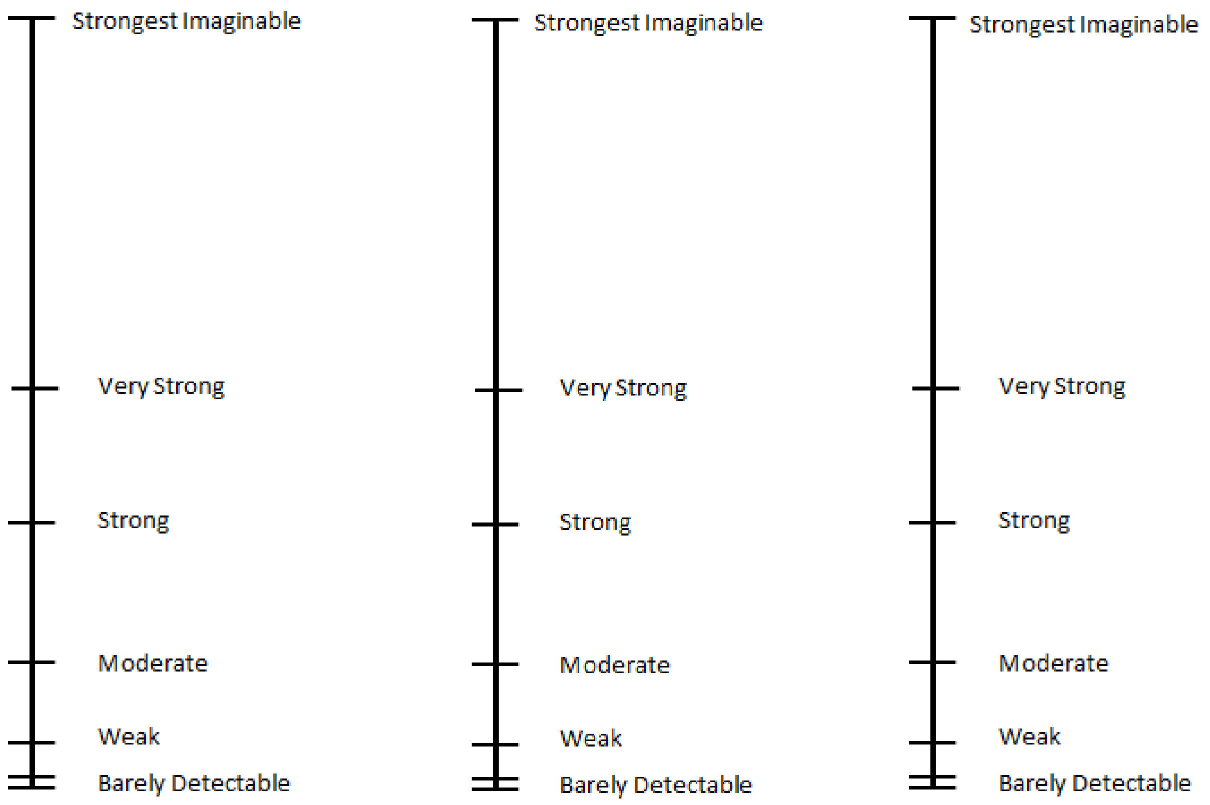


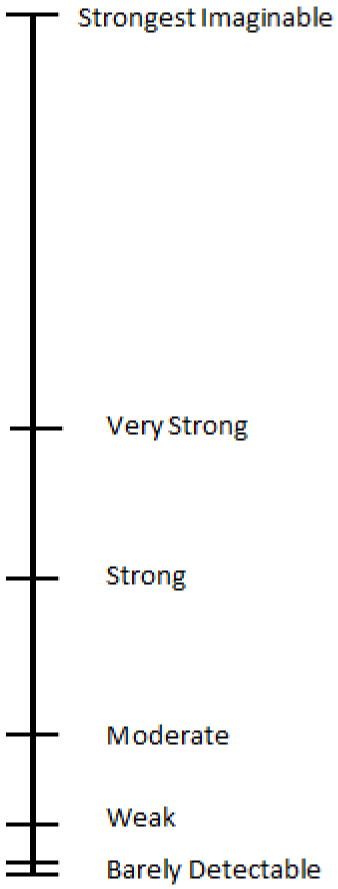
f. Tartaric Acid, Tannic Acid and Sucrose Intensities and Liking (Wine)

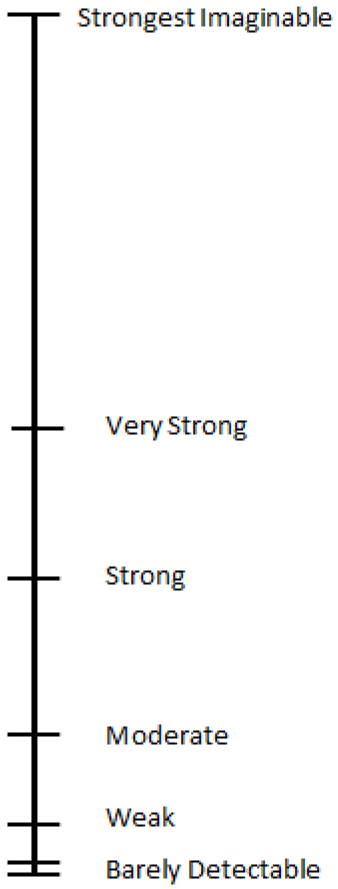
Date___/__/______

Name ____

Rinse with water before beginning. Put the sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation intensity to peak (10-15 s). The maximum intensity is 10 seconds after spiting. After you taste the first sample rate the intensity of the sensation by drawing a mark on the LMS Scale. Rinse with spring water and wait 1 minute between samples. Repeat the same procedure with the other 2 samples.




Strongest Imaginable
Very Strong
Strong
Moderate
Weak
Barely Detectable


Strongest Imaginable
Very Strong
Strong
Moderate
Weak
Barely Detectable

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.) The maximum intensity is 10 seconds after spiting. After, draw a mark on the liking scale according to your personal preference.

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

g. Aroma Intensity and Liking

Name **Date___/__/______**

____

Aroma Intensity

Place the glass on the table and start to approach it from your nose. When you feel the aroma of the wine stop and register the intensity of the aroma with the help of the ruler. Write down the distance (cm) on the table below.

The further away from your nose you smell the greater the aromatic intensity of the wine.

Rate the intensity of the four wines before tasting.

Wine	**Length (cm)**
1	
2	
3	
4	

Name **Date___/__/______**

____

Salt Intensity

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.) After, draw a mark on the scale according to the intensity.

1. Salt Intensity

Barely Detectable Strongest Imaginable

2. Salt Intensity

Barely Detectable Strongest Imaginable

3. Salt Intensity

Barely Detectable Strongest Imaginable

4. Salt Intensity

Barely Detectable Strongest Imaginable

Name **Date___/__/______**

Acidity Intensity

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.) After, draw a mark on the scale according to the intensity.

1. Acidity Intensity

Barely Detectable

Strongest Imaginable

2. Acidity Intensity

Barely Detectable

Strongest Imaginable

3. Acidity Intensity

Barely Detectable

Strongest Imaginable

4. Acidity Intensity

Barely Detectable

Strongest Imaginable

Name **Date___/__/______**

____

Intensity of Sweetness

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.) After, draw a mark on the scale according to the intensity.

1. Intensity of Sweetness

Barely Detectable Strongest Imaginable

2. Intensity of Sweetness

Barely Detectable Strongest Imaginable

3. Intensity of Sweetness

Barely Detectable Strongest Imaginable

4. Intensity of Sweetness

Barely Detectable Strongest Imaginable

Name **Date___/__/______**

Liking

Put the separate sample in the mouth, rinse for 10 seconds, being sure that you cover all the mouth surfaces and wait for the sensation to peak (1—15s.). After, draw a mark on the liking scale according to your personal preference.

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

Liking

Dislike extremely

Like extremely

2. Data

a. Demographic

Tasters	Age	Gender	Country	Study Background	Smoker	Vegetarian	Food Allergy	Vinotype	Wine Expertise
1	24	F	Portugal	Biochemistry	Y	N	N	Hypersensitive	Intermediate
2	23	F	Portugal	Agronomic Engineer	Y	N	N	Tolerant	Intermediate
3	21	F	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
4	22	F	Portugal	Biochemistry	N	N	N	Hypersensitive	Intermediate
5	22	F	Portugal	Food Engineer	N	N	N	Hypersensitive	Intermediate
6	30	M	Brasil	International Relations	N	N	N	Sensitive	Beginner
7	22	M	Portugal	Food Engineer	S	N	N	Sensitive	Intermediate
8	20	F	Portugal	Biology	Y	N	N	Sensitive	Intermediate
9	38	F	Brasil	Law	N	N	N	Hypersensitive	Intermediate
10	24	F	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
11	25	F	Germany	Wine business	Y	N	N	Sensitive	Very High
12	23	M	Portugal	Business	N	N	N	Tolerant	Intermediate
13	23	M	Portugal	High School	S	N	N	Sensitive	I don't drink wine
14	23	M	Portugal	Agronomic Engineer	Y	N	N	Hypersensitive	Intermediate
15	23	M	Portugal	Environment Engineer	S	N	N	Sensitive	Beginner
16	22	F	Portugal	Biology	N	N	N	Sensitive	I don't drink wine
17	22	F	Portugal	Agronomic Engineer	Y	N	N	Tolerant	Intermediate
18	23	M	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
19	23	M	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
20	23	M	Portugal	Environment Engineer	N	N	N	Hypersensitive	Very High
21	24	M	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
22	36	M	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
23	19	F	Portugal	Food Engineer	N	N	N	Sensitive	Beginner
24	23	F	Portugal	Architecture	Y	N	N	Sensitive	Beginner
25	24	F	Portugal	Food Engineer	Y	N	N	Sensitive	Beginner
26	37	F	Portugal	Agronomic Engineer	N	N	N	Sensitive	Intermediate
27	23	M	Portugal	Civil Engineer	Y	N	N	Hypersensitive	Beginner
28	22	F	Portugal	Biology	Y	N	N	Sensitive	Beginner
29	40	F	Portugal	Pharmacy	N	N	N	Tolerant	Intermediate
30	23	M	Portugal	Architecture	S	N	N	Sensitive	Beginner
31	23	F	Portugal	Architecture	Y	N	N	Sensitive	I don't drink wine
32	24	F	Portugal	Agronomic Engineer	N	N	Y	Sensitive	Intermediate
33	24	F	Portugal	Biology	N	N	N	Hypersensitive	Begnner
34	20	F	Portugal	Agronomic Engineer	Y	N	N	Hypersensitive	Beginner

b. PROP Status

Tasters	PROP 0.32 mM	PROP Status
1	0.30	NT
2	3.30	MT
3	1.10	NT
4	0.30	NT
5	2.00	MT
6	4.90	MT
7	4.20	MT
8	3.70	MT
9	1.20	NT
10	3.20	MT
11	2.70	MT
12	0.60	NT
13	3.20	MT
14	4.20	MT
15	1.60	MT
16	6.20	ST
17	2.50	MT
18	4.20	MT
19	2.40	MT
20	0.90	NT
21	1.80	MT
22	4.00	MT
23	2.60	MT
24	1.30	NT
25	3.70	MT
26	1.40	NT
27	0.70	NT
28	2.80	MT
29	3.60	MT
30	3.10	MT
31	0.00	NT
32	6.60	ST
33	0.30	NT
34	1.10	NT

c. Saliva Flow

Tasters	Initial Weight	Total Weight	Saliva Weight	Saliva Flow
1	9.30	9.80	0.50	LF
2	11.90	12.90	1.00	LF
3	8.70	9.80	1.10	LF
4	8.40	9.40	1.00	HF
5	8.60	9.70	1.10	LF
6	11.80	15.10	3.30	LF
7	8.80	12.50	3.70	HF
8	8.50	9.70	1.20	LF
9	8.40	9.30	0.90	LF
10	9.40	10.10	0.70	HF
11	8.80	11.60	2.80	HF
12	8.80	11.10	2.30	HF
13	11.80	14.70	2.90	HF
14	10.40	12.20	1.80	LF
15	8.50	10.20	1.70	LF
16	8.40	10.60	2.20	LF
17	11.10	13.60	2.50	HF
18	8.60	14.00	5.40	LF
19	9.40	12.10	2.70	LF
20	9.20	13.40	4.20	HF
21	8.40	14.90	6.50	LF
22	11.70	14.70	3.00	HF
23	11.80	13.10	1.30	HF
24	9.40	13.10	3.70	HF
25	11.90	14.20	2.30	HF
26	8.90	11.60	2.70	LF
27	10.40	13.30	2.90	HF
28	8.60	9.80	1.20	LF
29	8.80	10.20	1.40	HF
30	8.80	10.80	2.00	LF
31	10.40	12.20	1.80	LF
32	8.80	14.90	6.10	LF
33	9.20	10.70	1.50	LF
34	8.80	10.20	1.40	LF

d. Sodium Chloride Sensitivity

Tasters	Concentrations			Geometric Mean	Profile
	0.01	0.1	1		
1	0.30	4.50	9.40	2.33	H
2	0.50	2.00	6.20	1.84	H
3	0.30	2.20	5.70	1.56	H
4	0.30	2.40	6.50	1.67	H
5	0.10	3.90	5.20	1.27	H
6	0.40	1.90	1.80	1.11	L
7	0.90	3.90	7.90	3.03	H
8	0.10	2.80	4.80	1.10	L
9	0.40	0.80	2.10	0.88	H
10	0.30	2.90	6.30	1.76	H
11	1.20	3.30	4.00	2.51	H
12	0.10	0.60	3.50	0.59	L
13	0.50	1.00	1.80	0.97	L
14	0.40	4.30	9.60	2.55	L
15	0.60	1.00	1.60	0.99	H
16	1.00	3.00	8.00	2.88	L
17	0.30	1.80	3.70	1.26	L
18	2.10	4.10	8.00	4.10	L
19	1.50	1.80	2.60	1.91	H
20	0.30	1.40	2.00	0.94	L
21	1.00	2.50	5.00	2.32	L
22	0.50	1.10	3.70	1.27	L
23	0.50	2.20	3.40	1.55	L
24	0.10	1.00	2.10	0.59	H
25	0.50	1.80	3.70	1.49	L
26	0.50	4.40	7.00	2.49	L
27	0.30	1.80	3.70	1.26	L
28	0.40	1.80	6.90	1.71	L
29	0.30	1.20	5.30	1.24	H
30	0.10	0.50	1.80	0.45	H
31	0.01	1.60	3.00	0.36	L
32	0.40	5.00	9.90	2.71	L
33	0.60	4.60	9.40	2.96	L
34	0.60	1.70	4.60	1.67	L

e. Tartaric Acid Sensitivity (Water)

	Concentrations (g/L)				
Tasters	0.1	1.0	10.0	Geometric Mean	Profile
1	0.40	3.70	8.80	2.35	H
2	0.50	1.50	3.80	1.42	H
3	0.20	1.90	5.90	1.31	H
4	0.10	0.80	5.70	0.77	H
5	2.40	2.80	4.90	3.21	H
6	0.90	3.50	9.80	3.14	H
7	0.40	3.90	9.50	2.46	L
8	0.30	1.30	7.80	1.45	L
9	0.40	0.90	1.40	0.80	H
10	0.70	2.00	5.00	1.91	H
11	3.70	6.20	7.00	5.44	H
12	0.60	3.50	5.20	2.22	H
13	0.20	0.80	4.30	0.88	H
14	0.60	4.40	9.90	2.97	H
15	0.60	1.60	4.00	1.57	L
16	1.00	5.80	9.70	3.83	L
17	0.40	2.10	4.60	1.57	L
18	0.60	3.40	9.50	2.69	H
19	0.50	1.50	2.70	1.27	L
20	3.80	3.70	6.60	4.53	L
21	1.00	3.70	8.10	3.11	L
22	0.90	3.80	3.70	2.33	L
23	0.80	2.30	3.80	1.91	L
24	0.40	0.90	3.20	1.05	H
25	1.20	3.70	7.60	3.23	H
26	2.90	5.20	8.80	5.10	L
27	0.30	1.00	5.40	1.17	L
28	0.70	1.50	2.90	1.45	L
29	0.50	1.00	3.40	1.19	L
30	1.30	3.60	6.10	3.06	L
31	0.70	1.70	2.60	1.46	L
32	3.10	5.50	9.40	5.43	L
33	0.10	0.90	1.90	0.56	L
34	0.70	1.90	6.10	2.01	L

f. Tannic Acid Sensitivity (Water)

Tasters	Concentrations (g/L) 0.10	1.00	2.50	Geometric Mean	Profile
1	0.10	1.70	7.40	1.08	H
2	0.20	2.00	5.50	1.30	H
3	0.70	3.10	6.50	2.42	H
4	0.30	3.10	8.00	1.95	H
5	0.60	1.70	6.10	1.84	H
6	0.10	0.60	1.90	0.48	H
7	0.10	4.00	9.70	1.57	H
8	0.10	0.10	3.20	0.32	H
9	0.30	0.50	1.00	0.53	L
10	0.50	2.70	5.80	1.99	H
11	3.00	2.30	3.50	2.89	H
12	0.20	1.60	3.50	1.04	H
13	0.10	0.70	3.60	0.63	H
14	0.50	3.90	8.60	2.56	L
15	0.40	2.20	4.30	1.56	H
16	1.10	5.00	9.80	3.78	L
17	0.30	1.80	5.00	1.39	H
18	1.50	5.00	8.90	4.06	L
19	0.10	0.50	2.70	0.51	L
20	1.50	3.20	6.20	3.10	L
21	0.70	3.20	8.00	2.62	L
22	0.80	2.10	5.60	2.11	L
23	0.40	2.20	3.80	1.50	L
24	0.10	2.60	3.30	0.95	L
25	0.90	2.10	4.60	2.06	L
26	1.60	7.70	10.00	4.98	L
27	0.30	1.50	3.60	1.17	H
28	0.10	0.50	3.30	0.55	H
29	1.50	3.30	5.30	2.97	L
30	0.30	2.40	3.90	1.41	L
31	0.50	2.30	7.10	2.01	L
32	1.20	3.20	9.30	3.29	L
33	1.10	4.60	9.10	3.58	L
34	0.40	5.60	9.10	2.73	L

g. Sucrose Sensitivity (Water)

Tasters	Concentrations 0.05	0.21	0.42	Geometric Mean	Profile
1	1.40	3.60	4.70	2.87	H
2	0.70	1.80	2.50	1.47	H
3	0.80	3.20	4.20	2.21	H
4	0.90	2.50	6.40	2.43	H
5	1.00	2.50	4.00	2.15	H
6	0.80	3.70	5.00	2.46	H
7	1.00	4.80	7.80	3.35	H
8	0.30	3.30	7.30	1.93	H
9	0.80	1.40	2.10	1.33	H
10	0.90	3.00	4.40	2.28	L
11	3.80	4.90	5.50	4.68	L
12	0.60	1.50	1.60	1.13	L
13	0.30	2.50	3.50	1.38	L
14	2.50	6.40	9.70	5.37	L
15	0.20	0.70	3.00	0.75	H
16	0.50	2.60	3.40	1.64	H
17	0.80	3.00	4.90	2.27	L
18	1.40	3.50	6.70	3.20	L
19	0.70	2.50	2.50	1.64	L
20	1.80	3.50	6.10	3.37	L
21	0.80	1.90	3.10	1.68	L
22	1.00	2.60	3.80	2.15	L
23	0.80	1.40	3.10	1.51	L
24	0.50	0.70	0.90	0.68	H
25	0.80	3.00	4.60	2.23	H
26	1.10	7.20	9.80	4.27	H
27	0.50	1.50	2.00	1.14	L
28	0.80	1.60	3.00	1.57	L
29	0.60	2.00	3.40	1.60	L
30	0.80	1.70	3.10	1.62	L
31	0.01	2.60	3.30	0.44	L
32	1.90	5.00	9.90	4.55	L
33	0.80	3.80	7.30	2.81	L
34	1.20	3.80	4.80	2.80	L

h. Overall Sensitivities (Water)

Tasters	Geometric Mean	Profile
1	1.86	L
2	1.86	L
3	1.55	L
4	1.45	L
5	2.02	H
6	1.73	L
7	2.87	H
8	1.24	L
9	0.90	L
10	1.93	L
11	3.69	H
12	1.11	L
13	1.16	L
14	3.19	H
15	1.25	L
16	3.35	H
17	1.61	L
18	3.57	H
19	1.35	L
20	2.55	H
21	2.24	H
22	2.16	H
23	1.58	L
24	0.91	L
25	2.31	H
26	3.49	H
27	1.12	L
28	1.37	L
29	1.99	L
30	1.89	L
31	0.86	L
32	4.30	H
33	2.02	H
34	2.34	H

i. Sweet Liking

Tasters	Concentration 205 g/L	Profile
1	5.70	Disliker
2	5.60	Disliker
3	8.60	Liker
4	6.20	Disliker
5	4.70	Disliker
6	1.00	Disliker
7	10.70	Liker
8	3.30	Disliker
9	3.10	Disliker
10	5.20	Disliker
11	0.40	Disliker
12	7.50	Liker
13	2.00	Disliker
14	3.30	Disliker
15	13.20	Liker
16	12.20	Liker
17	2.70	Disliker
18	3.40	Disliker
19	3.30	Disliker
20	2.60	Disliker
21	6.30	Disliker
22	10.70	Liker
23	4.20	Disliker
24	13.00	Liker
25	4.30	Disliker
26	0.50	Disliker
27	8.80	Liker
28	11.50	Liker
29	4.40	Disliker
30	10.50	Liker
31	5.70	Disliker
32	4.20	Disliker
33	7.10	Disliker
34	9.50	Liker

j. Tartaric Acid Intensity and Preference (Wine)

Tasters	Intensity Concentrations (g/L)					Liking Concentrations (g/L)				
	0.15	**0.30**	**0.60**	**1.20**	**2.40**	**0.15**	**0.30**	**0.60**	**1.20**	**2.40**
1	4.40	6.50	1.50	6.40	3.60	8.00	6.00	9.90	6.50	7.00
2	6.10	7.00	4.50	1.40	5.10	8.00	7.40	7.50	9.60	7.80
3	5.50	4.70	8.20	7.10	7.90	5.90	5.80	6.00	4.20	4.50
4	4.00	4.00	3.00	3.00	4.20	3.20	0.50	3.20	3.40	2.40
5	3.40	5.40	5.50	5.00	7.40	3.50	5.90	4.00	4.50	1.80
6	2.60	1.70	2.70	4.20	2.00	11.50	8.20	11.40	11.50	11.50
7	4.00	4.40	4.50	4.50	3.20	6.70	8.90	3.00	10.60	4.80
8	2.70	6.10	2.00	5.80	3.70	7.50	5.20	8.70	4.90	6.80
9	2.10	1.80	5.40	2.90	7.00	8.50	11.80	3.30	9.10	2.40
10	6.00	6.70	5.60	7.10	3.20	10.80	10.40	9.20	8.40	11.80
11	3.00	6.00	5.40	5.60	6.80	7.00	0.70	7.50	3.40	4.50
12	5.30	5.40	4.80	5.40	4.70	9.00	6.40	5.00	7.20	5.20
13	2.50	4.80	1.10	3.70	6.70	4.50	4.40	5.40	5.50	3.70
14	8.40	2.10	7.20	5.30	9.00	5.50	7.90	6.60	8.80	7.50
15	6.00	6.40	7.50	6.10	7.70	9.20	8.90	13.00	9.00	10.50
16	6.00	7.40	4.60	7.60	6.70	4.60	3.40	5.70	3.60	4.80
17	7.10	2.70	6.30	7.60	8.40	6.90	8.20	10.30	6.20	7.10
18	7.40	7.40	7.00	8.00	8.30	9.60	9.30	8.50	10.20	9.40
19	2.40	2.40	2.40	2.70	4.70	5.70	4.00	7.80	5.40	7.90
20	2.90	3.70	5.50	7.80	5.30	10.80	6.30	9.80	5.30	6.60
21	2.70	6.00	6.80	6.10	8.00	9.00	8.10	10.00	8.50	8.70
22	0.70	5.90	4.70	7.80	8.00	10.70	12.50	10.70	6.80	3.50
23	2.80	5.70	4.10	3.80	1.90	5.80	5.80	8.80	7.00	4.50
24	5.70	3.90	2.90	3.70	4.40	6.60	6.10	6.70	7.10	5.60
25	0.60	0.80	5.50	2.10	3.50	9.30	14.00	0.90	3.80	5.80
26	2.50	4.60	2.50	1.90	3.50	3.20	0.90	0.50	0.01	0.20
27	1.00	4.80	2.00	5.30	5.40	4.90	9.20	4.30	3.40	3.40
28	4.50	5.20	4.20	4.90	3.80	4.80	4.00	7.00	6.30	7.00
29	0.20	3.70	1.00	2.00	4.10	11.20	7.00	6.50	7.20	5.50
30	3.60	6.10	3.90	5.50	5.80	3.10	0.90	1.70	1.80	1.40
31	7.50	5.00	6.30	6.30	7.10	1.10	6.60	3.20	5.80	3.40
32	2.00	3.00	0.50	7.20	6.10	5.50	6.80	4.20	10.00	8.00
33	6.00	0.80	3.60	7.80	8.00	4.40	11.70	8.40	1.30	4.30
34	3.50	5.20	6.30	5.40	6.90	4.40	6.40	5.20	7.20	5.60

k. Tannic Acid Intensity and Preference (Wine)

	Intensity Concentrations (g/L)					Liking Concentrations (g/L)				
Tasters	**0.09**	**0.19**	**0.38**	**0.75**	**1.50**	**0.09**	**0.19**	**0.38**	**0.75**	**1.50**
1	6.70	7.60	5.90	7.00	6.70	5.20	7.00	3.30	7.00	2.00
2	2.20	2.00	5.70	4.80	7.70	9.20	8.50	4.70	7.70	3.50
3	7.10	6.40	6.70	6.10	8.30	3.30	5.30	5.80	5.00	3.00
4	6.20	8.80	5.30	7.90	6.50	1.10	0.60	2.30	0.60	1.20
5	0.50	5.80	5.50	6.20	7.50	7.50	1.90	2.50	1.50	1.00
6	5.50	4.80	3.90	7.80	8.20	4.00	4.00	10.00	3.50	4.00
7	5.50	7.70	4.20	7.20	6.50	1.00	0.10	3.00	0.20	0.40
8	1.10	1.80	0.50	2.00	1.90	7.40	7.30	7.40	6.40	6.20
9	7.90	8.70	6.50	8.40	7.90	3.40	0.80	4.70	0.90	1.60
10	4.70	3.00	6.50	8.10	7.30	9.80	10.80	9.90	4.80	8.00
11	3.00	7.10	3.80	6.60	6.50	2.60	0.30	5.50	0.60	0.40
12	4.10	6.80	3.00	6.30	4.40	6.30	4.10	5.00	5.00	2.70
13	0.40	4.50	3.70	6.50	5.90	6.80	4.10	6.90	1.70	4.20
14	3.00	4.20	3.20	5.20	8.00	6.50	9.50	7.10	8.60	7.90
15	6.00	6.20	7.40	5.00	8.00	5.50	5.50	10.10	6.10	2.60
16	7.60	8.80	5.00	8.80	7.60	3.80	0.70	6.10	2.00	3.80
17	6.00	5.30	7.70	4.80	7.10	7.70	8.00	7.00	8.30	7.00
18	5.60	7.90	7.30	7.70	9.20	8.20	8.40	10.20	4.20	2.00
19	1.60	0.30	2.10	4.80	2.80	3.50	4.00	5.80	7.80	7.80
20	3.00	4.00	3.70	4.80	3.30	7.00	8.30	8.70	5.30	6.60
21	4.30	4.00	7.30	4.80	8.30	11.60	11.50	10.70	11.00	11.00
22	5.50	8.90	5.30	9.10	7.20	8.20	2.50	7.20	2.70	5.70
23	4.60	5.50	5.30	6.10	5.30	5.60	6.50	7.70	6.30	5.70
24	6.50	8.10	6.30	7.60	6.60	5.10	3.00	5.20	3.40	4.60
25	3.70	4.20	6.10	0.50	5.50	7.00	11.50	7.90	9.30	8.20
26	4.90	5.70	5.90	2.50	5.70	3.80	2.50	1.60	0.20	0.20
27	2.00	3.80	6.20	4.20	7.10	5.00	8.50	3.20	6.00	0.70
28	4.00	4.80	3.70	5.20	4.20	5.00	5.60	6.70	4.50	5.30
29	1.00	0.70	5.30	5.20	7.70	7.70	7.10	4.60	7.00	2.90
30	6.20	6.30	6.00	6.20	6.00	0.60	1.00	1.80	0.70	0.80
31	5.00	7.10	5.00	4.70	8.10	3.80	1.90	3.20	3.80	1.80
32	0.60	0.40	6.20	6.10	7.10	9.40	7.20	7.70	8.70	4.10
33	5.50	6.90	8.80	7.70	9.10	8.00	2.10	0.50	0.70	0.50
34	7.10	6.70	6.30	7.50	7.20	4.10	6.60	3.60	6.80	1.70

I. Sucrose Intensity and Preference (Wine)

Tasters	Intensity Concentrations (g/L)					Liking Concentrations (g/L)				
	6.00	12.00	24.00	48.00	96.00	6.00	12.00	24.00	48.00	96.00
1	5.3	6.4	3	6.7	5.4	6.2	4.5	7.7	5.6	7.3
2	0.2	0.1	2.3	3.2	3.2	7.6	7.2	7.1	7	6.3
3	4.7	4.8	3.5	4.7	5.4	5.4	4.3	6.8	9	8.9
4	3.1	3.3	1.7	5.9	3.9	6.2	7	6.7	4.4	5.3
5	1.8	2.8	5	7.1	8.2	2.1	7.2	7.5	5.8	4.7
6	0.4	0.7	5.1	5.3	4.1	0.6	2.3	4	0.7	3.9
7	1.7	1.4	2.8	2.2	4.3	8.1	7	2.8	3.1	1.3
8	3.8	2.7	1.5	4.4	4.7	7.4	8.6	8.3	7.2	6.6
9	5.5	6.2	4.7	3	3	5.7	3.4	6.7	6.8	6.7
10	1.3	1.7	5.7	6.5	8	10.4	10.6	10.5	8	4.2
11	6	4	8.1	0.4	9.5	3.5	4	1.5	0.4	0.3
12	4.7	2.8	3.1	3.5	1.8	5.8	4.3	8.3	7.2	6.8
13	0.7	0.2	5.4	6.2	6.4	7.7	8.3	3.3	1.1	0.4
14	3.3	2.4	7.8	8.5	9.6	8.3	9.6	4.7	3.8	1.5
15	6.3	5	6.4	7.4	7.5	7.5	8.5	11.2	9	11.8
16	4.9	3	0.2	6.3	1.8	6.3	8.2	7.5	9.9	9
17	5.2	6.3	6.1	7.5	7.9	7.3	6.3	4.7	2	1.7
18	7.4	7.2	5.4	3.7	3.6	10.3	10.8	7.9	4.4	5.6
19	1	1.5	2.3	1	1.3	4.1	3.3	4.6	3.7	3.9
20	1.3	1.4	4.2	5.2	5.8	6.5	6.7	2.8	2.8	4
21	3.8	4	6.6	6.1	8.4	8.6	8.4	7.6	7.2	6.9
22	4	4.1	5.3	6.6	8	8.4	8.4	3.6	3.3	3.3
23	5.8	5.5	4.2	4.5	4.7	5.1	7.3	7	4.9	4.7
24	6.4	3.6	2.9	5.8	3.8	4.6	7.3	8.9	8.8	8.8
25	4.7	4.3	1.2	4.7	4.2	8.2	7	11.7	10.3	10.4
26	1.5	1.8	0.9	0.6	0.6	7.4	6.3	2.3	0.5	0.1
27	2	2.4	3.1	3.2	4.4	4.2	4.1	7.8	7.2	7.8
28	3.1	2.9	4.8	5.4	6.1	4.2	4	7.8	7.5	7.2
29	1.1	1.5	3.3	4.5	5.5	9.7	10.1	8.8	7.3	6
30	5.3	6.7	4.8	6.3	5.4	3.5	7	8.1	6.1	5.1
31	7.4	1.3	5	7.4	6	1.9	9	6.2	1.8	3.9
32	2.7	1.2	8	9.5	9.7	10.4	11.9	3.5	0.4	0.5
33	1.4	1.8	2.9	4.7	6.5	11.8	10.9	10	8.2	7.1
34	3.3	4.5	2.9	4.3	2.7	2	3.5	2.7	4.4	3.3

m. Aroma Intensity and Sensitivity

Tasters	Aroma Intensity 0	0.5	1	2	Geometric Mean	Sensitivity
1	10.50	9.80	8.70	7.00	8.90	L
2	3.00	4.00	5.00	5.00	4.16	L
3	6.50	7.20	8.00	11.00	8.01	L
4	9.00	10.00	8.50	15.00	10.35	H
5	10.00	8.00	11.50	14.00	10.65	H
6	12.00	9.00	9.00	8.00	9.39	H
7	7.50	8.00	10.50	8.00	8.43	L
8	5.00	10.00	9.50	11.00	8.50	L
9	5.00	7.00	6.00	7.00	6.19	L
10	6.00	7.50	9.00	9.50	7.88	L
11	17.00	14.00	12.00	17.00	14.84	H
12	4.50	8.00	10.00	6.00	6.82	L
13	8.50	10.00	17.00	20.00	13.04	H
14	8.00	6.00	6.00	8.00	6.93	L
15	5.60	10.00	12.00	7.00	8.28	L
16	15.00	14.00	17.00	16.00	15.46	H
17	9.00	13.00	10.00	16.00	11.70	H
18	7.00	11.00	14.50	15.00	11.38	H
19	16.00	8.00	8.00	10.00	10.06	H
20	6.00	6.00	7.00	11.00	7.26	L
21	5.00	3.00	5.00	4.00	4.16	L
22	4.00	5.80	7.80	12.00	6.83	L
23	0.50	5.00	2.00	10.00	2.66	L
24	2.00	4.00	5.00	10.00	4.47	L
25	8.50	13.00	13.00	13.00	11.69	H
26	3.50	6.00	7.50	7.50	5.86	L
27	2.50	6.00	4.00	4.00	3.94	L
28	13.00	15.00	14.00	13.00	13.73	H
29	8.00	7.00	9.00	6.50	7.57	L
30	15.00	12.50	14.00	15.50	14.20	H
31	8.00	7.50	8.50	8.50	8.11	L
32	8.50	6.50	8.00	11.50	8.44	L
33	12.00	12.00	12.50	13.00	12.37	H
34	17.00	15.00	14.00	15.00	15.21	H

n. Sweetness, Acidity, Saltiness and Liking Intensity

Tasters	Sweetness Intensity				Acidity Intensity				Saltiness Intensity				Liking			
	0	0.5	1	2	0	0.5	1	2	0	0.5	1	2	0	0.5	1	2
1	7.70	5.20	4.00	1.40	4.50	6.00	7.00	9.00	6.80	5.50	4.60	7.00	7.30	6.10	4.50	3.20
2	3.30	2.70	3.80	4.00	6.20	7.00	4.90	5.30	4.30	2.30	6.70	6.30	6.90	7.80	5.90	8.10
3	3.30	0.60	0.60	3.20	6.20	8.50	5.40	8.30	2.50	4.60	5.70	4.50	4.70	7.00	10.80	8.60
4	0.30	1.60	2.30	4.80	4.00	3.00	0.40	0.10	2.20	1.50	1.80	1.20	1.30	1.90	5.70	6.30
5	1.70	2.00	2.00	2.00	7.50	7.00	7.20	8.10	5.00	5.00	5.00	5.00	11.20	7.20	5.80	4.30
6	0.60	2.80	2.90	2.90	3.50	2.20	2.20	3.60	6.80	4.40	3.40	2.70	7.00	6.70	6.60	11.40
7	0.50	1.50	1.10	2.70	6.10	7.00	4.10	6.10	6.10	6.20	4.00	5.70	8.00	6.00	8.00	10.10
8	0.50	1.70	2.70	2.30	5.40	6.90	5.60	6.40	7.20	4.40	3.30	4.70	3.30	4.70	4.70	5.00
9	3.30	2.00	0.90	0.70	5.70	6.30	3.30	4.20	2.90	7.90	5.40	4.60	9.50	6.70	7.00	7.00
10	2.90	2.20	5.30	4.50	7.00	7.20	5.30	5.50	6.20	6.80	5.30	5.50	6.40	5.50	7.40	7.70
11	1.10	2.50	5.70	7.50	5.50	4.60	4.00	4.30	5.50	4.70	6.50	6.60	2.80	1.60	2.00	0.90
12	6.80	4.60	4.70	3.00	5.00	6.40	3.00	3.30	8.50	3.20	6.10	3.20	7.50	12.30	10.00	10.00
13	0.30	0.70	0.60	1.70	1.20	2.00	1.70	1.80	4.50	2.80	2.00	3.70	3.30	4.00	5.40	6.40
14	6.30	5.50	6.00	7.20	7.80	8.20	8.50	6.40	5.50	7.30	7.20	6.80	9.20	11.30	11.30	5.80
15	7.50	6.00	5.00	6.90	6.00	7.50	7.50	3.80	3.50	4.00	5.00	6.40	12.80	9.40	9.20	9.20
16	2.70	3.80	4.70	4.80	3.90	5.90	3.50	5.60	5.70	5.00	5.70	5.50	7.50	6.90	7.50	7.20
17	0.90	1.60	2.30	3.00	7.00	5.30	4.60	5.20	3.00	4.20	4.30	2.90	10.20	9.30	7.00	4.90
18	1.40	3.50	4.80	6.20	7.30	5.90	5.20	5.60	0.20	0.10	0.20	0.90	9.30	8.00	7.50	4.10
19	2.30	5.40	5.40	7.00	7.30	1.80	2.10	4.90	3.70	3.50	3.30	3.80	5.90	7.80	7.90	7.20
20	2.20	2.70	3.10	4.70	5.20	3.90	5.70	5.70	3.00	3.10	4.70	6.20	6.20	5.70	8.10	9.00
21	5.10	3.70	5.90	4.60	6.60	5.50	5.80	4.30	4.50	5.10	4.30	7.40	7.80	9.60	7.70	7.90
22	2.00	3.20	7.00	8.20	5.40	7.00	8.20	6.80	6.00	7.20	7.80	6.50	5.40	7.00	9.20	5.00
23	1.30	3.40	6.40	6.30	3.60	3.40	1.70	5.50	6.00	6.00	3.50	3.20	8.70	6.00	5.70	8.20
24	0.10	1.00	1.90	0.20	8.70	6.30	3.60	9.70	1.90	1.30	2.20	2.00	2.00	5.70	5.00	2.80
25	3.50	4.70	4.70	4.70	2.00	0.30	0.20	0.20	1.10	0.20	0.40	0.20	5.50	7.50	7.50	7.50
26	0.10	1.20	2.50	7.50	6.20	2.50	3.00	6.60	4.30	2.50	0.60	1.10	4.00	2.50	3.00	0.30
27	5.40	0.70	4.50	3.40	3.00	5.40	4.50	5.40	1.90	4.80	3.40	3.20	3.30	3.50	4.30	4.40
28	4.20	0.20	5.20	6.10	5.90	6.60	5.70	5.80	4.20	5.70	0.10	0.10	7.70	6.30	7.60	8.50
29	4.20	2.10	3.50	4.80	3.40	4.90	6.70	4.60	2.20	1.50	2.30	1.40	7.80	10.10	11.00	10.40
30	0.60	7.30	3.20	0.20	7.80	0.20	1.20	5.70	4.60	1.00	1.30	7.70	7.20	11.50	8.00	5.30
31	3.70	4.40	6.20	3.70	5.00	5.00	6.10	7.50	8.70	6.20	7.50	8.30	7.50	9.20	5.60	3.10
32	0.70	3.60	6.20	8.80	8.10	6.10	7.20	8.20	0.70	0.70	3.30	4.60	10.10	12.10	5.10	3.40
33	5.50	7.20	2.30	4.70	3.80	3.10	3.50	7.80	4.40	5.60	5.40	6.80	12.40	11.00	8.30	8.30
34	2.80	1.50	4.40	2.20	5.60	7.80	7.40	8.20	7.80	5.90	5.60	4.70	10.70	9.00	4.80	4.60

o. ANOVA

Categories	Wine	P-values	Mean ± sd
Tartaric Acid Intensity	1	0.00567	3.97^{b}±2.13
	2		4.62^{ab}±1.83
	3		4.38^{ab}±2.03
	4		5.20^{ab}±1.95
	5		5.65^{a}±2.00
Tannic Acid Intensity	1	0.000165	4.37^{b}±2.19
	2		5.43^{ab}±2.45
	3		5.33^{ab}±1.71
	4		5.98^{a}±1.92
	5		6.65^{a}±1.72
Sucrose Intensity	1	9.23E-05	3.56^{b}±2.10
	2		3.22^{b}±1.96
	3		4.12^{ab}±2.02
	4		5.06^{a}±2.13
	5		5.33^{a}±2.43

Categories	Wine	P-values	Mean ± sd
Tartaric Acid Liking	1	0.565	6.77^{a}±2.71
	2		6.75^{a}±3.30
	3		6.58^{a}±3.11
	4		6.27^{a}±2.78
	5		5.73^{a}±2.78
Tannic Acid Liking	1	0.0302	5.72^{ab}±2.62
	2		5.19^{ab}±3.40
	3		5.81^{a}±2.74
	4		4.65^{ab}±3.03
	5		3.78^{b}±2.81
Sucrose Liking	1	0.0271	6.38^{a}±2.72
	2		6.97^{a}±2.51
	3		6.48^{a}±2.68
	4		5.28^{a}±2.94
	5		5.15^{a}±2.98

Categories	Wine	Profile	P-values	Mean ± sd
Aroma Intensity	1	H	2.97E-07	$12.07^{a}\pm3.47$
		L		$5.48^{b}\pm2.50$
	2	H	1.36E-07	$11.75^{a}\pm2.44$
		L		$6.71^{b}\pm1.92$
	3	H	4.02E-06	$12.50^{a}\pm2.87$
		L		$7.42^{b}\pm2.44$
	4	H	2.12E-07	$14.32^{a}\pm2.93$
		L		$8.22^{b}\pm2.46$
Sweetness Intensity	1	H	0.0821	$1.99^{a}\pm1.59$
		L		$3.34^{a}\pm2.48$
	2	H	0.654	$3.20^{a}\pm2.25$
		L		$2.90^{a}\pm1.63$
	3	H	0.476	$3.60^{a}\pm1.57$
		L		$4.06^{a}\pm1.98$
	4	H	0.737	$4.13^{a}\pm2.18$
		L		$4.40^{a}\pm2.45$
Acidity Intensity	1	H	0.348	$5.16^{a}\pm2.13$
		L		$5.75^{a}\pm1.49$
	2	H	0.00535	$3.97^{b}\pm2.50$
		L		$6.05^{a}\pm1.54$
	3	H	0.0144	$3.49^{a}\pm2.33$
		L		$5.35^{a}\pm1.86$
	4	H	0.0792	$4.77^{a}\pm2.61$
		L		$6.13^{a}\pm1.74$
Saltiness Intensity	1	H	0.569	$4.19^{a}\pm2.07$
		L		$4.63^{a}\pm2.29$
	2	H	0.19	$3.54^{a}\pm2.06$
		L		$4.53^{a}\pm2.15$
	3	H	0.0531	$3.21^{a}\pm2.25$
		L		$4.64^{a}\pm1.89$
	4	H	0.125	$3.70^{a}\pm2.49$
		L		$4.93^{a}\pm2.04$
Liking	1	H	0.722	$7.28^{a}\pm3.31$
		L		$6.92^{a}\pm2.62$
	2	H	0.717	$7.05^{a}\pm2.93$
		L		$7.41^{a}\pm2.74$
	3	H	0.415	$6.54^{a}\pm1.69$
		L		$7.17^{a}\pm2.48$
	4	H	0.794	$6.20^{a}\pm2.51$
		L		$6.46^{a}\pm2.91$

Categories	Wine	P-values	Mean ± sd
Low Responsive Aroma Intensity	1	0.00347	5.48^{b}±2.50
	2		6.71^{ab}±1.93
	3		7.43^{ab}±2.44
	4		8.23^{a}±2.46
Low Responsive Sweetness Intensity	1	0.123	3.34^{a}±2.48
	2		2.90^{a}±1.63
	3		4.07^{a}±1.98
	4		4.40^{a}±2.45
Low Responsive Acidity Intensity	1	0.452	5.75^{a}±1.49
	2		6.05^{a}±1.54
	3		5.35^{a}±1.86
	4		6.13^{a}±1.74
Low Responsive Saltiness Intensity	1	0.94	4.63^{a}±2.29
	2		4.53^{a}±2.15
	3		4.64^{a}±1.89
	4		4.93^{a}±2.04
Low Responsive Liking Intensity	1	0.714	6.92^{a}±2.62
	2		7.41^{a}±2.74
	3		7.17^{a}±2.48
	4		6.46^{a}±2.91

Categories	Class	P-values	Mean ± sd
Aroma Intensity	H	2.00E-16	12.66^{a}±3.04
	L		6.96^{b}±2.51
Sweetness Intensity	H	0.232	3.23^{a}±2.03
	L		3.68^{a}±2.20
Acidity Intensity	H	5.02E-05	4.35^{b}±2.43
	L		5.82^{a}±1.66
Saltiness Intensity	H	0.00642	3.66^{b}±2.19
	L		4.68^{a}±2.06
Liking	H	0.636	6.77^{a}±2.64
	L		6.99^{a}±2.66

Perception	Categories	Class	P-values	Mean ± sd	Number of Tasters
Aroma Intensity	Tartaric Acid	H	0.179	$9.81^{a}\pm3.76$	15
		L		$8.90^{a}\pm4.03$	19
	Tannic Acid	H	0.314	$9.67^{a}\pm3.82$	16
		L		$8.99^{a}\pm4.00$	18
	Sucrose	H	0.049*	$10.09^{a}\pm3.35$	14
		L		$8.75^{b}\pm4.21$	20
	Overall	H	0.035*	$10.15^{a}\pm3.98$	14
		L		$8.71^{b}\pm3.79$	20
Sweetness Intensity	Tartaric Acid	H	0.173	$3.78^{a}\pm2.26$	15
		L		$3.27^{a}\pm2.02$	19
	Tannic Acid	H	0.00309*	$4.04^{a}\pm1.99$	16
		L		$2.98^{b}\pm2.14$	18
	Sucrose	H	0.943	$3.51^{a}\pm2.22$	14
		L		$3.48^{a}\pm2.09$	20
	Overall	H	0.0642	$3.90^{a}\pm2.16$	14
		L		$3.21^{a}\pm2.09$	20
Acidity Intensity	Tartaric Acid	H	0.638	$5.31^{a}\pm2.25$	15
		L		$5.14^{a}\pm2.04$	19
	Tannic Acid	H	0.0663	$5.58^{a}\pm1.99$	16
		L		$4.90^{a}\pm2.21$	18
	Sucrose	H	0.304	$5.44^{a}\pm2.02$	14
		L		$5.06^{a}\pm2.21$	20
	Overall	H	0.0859	$5.59^{a}\pm2.08$	14
		L		$4.95^{a}\pm2.14$	20
Saltiness Intensity	Tartaric Acid	H	0.946	$4.27^{a}\pm2.37$	15
		L		$4.25^{a}\pm2.01$	19
	Tannic Acid	H	0.369	$4.44^{a}\pm2.46$	16
		L		$4.10^{a}\pm1.88$	18
	Sucrose	H	0.885	$4.29^{a}\pm2.19$	14
		L		$4.24^{a}\pm2.17$	20
	Overall	H	0.506	$4.41^{a}\pm2.34$	14
		L		$4.16^{a}\pm2.06$	20

Perception	Categories	Class	P-values	Mean ± sd	Number of Tasters
Liking	Tartaric Acid	H	0.575	$6.75^{a}\pm2.74$	15
		L		$7.01^{a}\pm2.59$	19
	Tannic Acid	H	0.508	$7.06^{a}\pm2.82$	16
		L		$6.76^{a}\pm2.49$	18
	Sucrose	H	0.308	$6.62^{a}\pm3.08$	14
		L		$7.09^{a}\pm2.29$	20
	Overall	H	0.831	$6.96^{a}\pm2.88$	14
		L		$6.86^{a}\pm2.49$	20